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STEAME ACADEMY
TEACHING FACILITATION LEARNING & CREATIVITY PLAN (L&C PLAN) - LEVEL 1
STUDENT TEACHERS: MAKING A NEWTON'S CRADLE - CONSERVATION OF MOMENTUM, MASS, AND VALOCITY

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1. Overview

Title	Making a Newton's Cradle - conservation of momentum, mass, and valocity
Driving Question or Topic	*How does a Newton's Cradle demonstrate the principles of conservation of momentum and energy, and how can we apply these principles to design and optimize real-world systems?*
Ages, Grades, …	*13-15* *K7-K9*
Duration, Timeline, Activities	*135 minutes* *4 X 45 Learning hours* *4 activities*
Curriculum Alignment	*The learning activity aligns with most EU countries' curriculum, with the subject of science as well as the subject of mathematics, used to describe the different aspects of the specific science topic. Furthermore, students will utilize engineering skills, in some EU countries, these skills are addressed through the subject of STEM or Technology.*
Contributors, Partners	
Abstract - Synopsis	
References, Acknowledgements	Online Simulations of Newtons Cradle: MyPhysicsLab.com (https://www.myphysicslab.com/engine2D/newtons-cradle-en.html), with graphs, visualimyPhysicsLab Newton's Cradlezation of forces, energy, etc. University of Alberta (https://sites.ualberta.ca/~dnobes/Teaching_Section/NOBES_SIM_Newton.html)

2. STEAME ACADEMY Framework*

Teachers' Cooperation	*A cooperation among teachers of different STEAME subject is advised to plan for and implement the proposed activity. Mainly a science teacher in collaboration with a math teacher. The first will input the core of the activity, that relates to the subject of science, and the latter will support the activity by ensuring the appropriate prior knowledge as well as to facilitate some aspects of the activity, mainly related to comprehend the mathematics that describe the science experiment as well as to help students understand the visual representation of specific aspects of the experiments (e.g., velocity/time, etc.) and how this visual representation is mathematically linked to the equations that describe the*

	experiment. Wider cooperation is possible with the STEM/STEAM or Technology teacher, as well as the art teacher in creating the cradles in the context of handcrafting.
STEAME in Life (SiL) Organization	*Meeting with business representatives/Applications in real world Entrepreneurship – STEAME in Life (SiL) Days*
Action Plan Formulation	*STAGE I: The activity encompasses the cooperation of two or more teachers, mainly the science teacher, with the math teacher to ensure an adequate level of knowledge and skills in the mathematics that explain the science experiment. STAGE II: All steps have been considered in formulating the learning activity action plan. The relation with a real life problem is evident through out the activity, introduced by the teacher, explaining the world around us, the movement, the momentum, gravity, the interaction between colliding objects, etc. allowing students to use this knowledge in their everyday life activities and everyday life problem solving, to the extent that it relates to these basic, and important laws of physics.*

[*] *under development the final elements of the framework*

3. Objectives and Methodologies

Learning Goals and Objectives	*-Explore how momentum and energy are conserved in an elastic collision using a Newton's Cradle.* *- Use mathematical equations related to momentum, mass, and velocity to predict the behavior of a Newton's Cradle.* *- Engage in hands-on engineering by building their own Newton's Cradle using various materials.* *- Consider aesthetics in the design of their Newton's Cradle, making it visually appealing while maintaining functionality.*
Learning Outcomes and expected Results	*The activity aims to achieve the following learning objectives so that students, upon completion are able to:* *- Understand the principles of conservation of momentum and energy* *- Apply mathematical formulas to predict outcomes* *- Design and construct a Newton's Cradle* *- Explore the artistic aspects* *Some of the skills addressed are Scientific Inquiry, Mathematical Application, Engineering and Design, Collaboration, Communication, Artistic and Creative Thinking*
Prior Knowledge and Prerequisites	*Students participating in this activity should have:* *- Basic Understanding of Newton's Laws of Motion* *- Knowledge of Basic Algebra and Physics Equations* *- Introduction to Kinetic and Potential Energy* *- Understanding of the Conservation Laws*
Motivation, Methodology, Strategies, Scaffolds	*This learning activity utilizes a project-based approach by engaging students to work in teams, inquire and explore to understand the basics science principles related to Newtons Cradle as well as the mathematic formulas that describe it. Students will have to explore, plan, implement, and test (through observations) if the Newton's Cradle they designed functions properly. This approach would also be considered as experiential learning.*

4. Preparation and Means

Preparation, Space Setting, *Troubleshooting Tips*	*The teacher/s do not need to prepare a lot, as what is needed is the tools and materials related to this activity. The classroom setting in the activities that students work together to design and construct their own Newton's Cradle should consider the facilitation of collaboration, preferably by providing different working stations for the student teams (e.g., desks put together to form a table that will allow the members of the team to sit around and work together).*
Resources, Tools, Material, Attachments, Equipment	*The teacher/s for this activity will need the following:* - *Steel balls or marbles (5 of identical size)* - *String or fishing line* - *Wooden or metal frame (can be pre-built or student-made)* - *Glue, tape, or fasteners* - *Measuring tape or ruler* - *Stopwatch* - *Calculator* - *Paint, markers, or other decorative materials (optional for artistic design)* - *Worksheets for calculations and predictions*
Health and Safety	*Health and safety for this activity needs to focus on the use of the materials to construct Newton's Cradle. It is not foreseen, but in case students use scissors, the teacher/s must consider the establishment of rules on how to safely handle scissors while working in teams. There is no other aspect that would require further caution than in any other everyday school class activity.*

5. Implementation

Instructional Activities, Procedures, Reflections	**Phase 1 - Introduction and Conceptual Understanding (45 minutes)** **Introduction (10 minutes)** Start with a demonstration of a Newton's Cradle. Discuss observations: What happens when one ball is lifted and released? What about two balls? Pose the question: Why does the last ball in line move while the others stay still? **Lecture and Discussion (15 minutes)** Explain the concepts of momentum, conservation of momentum, and energy in elastic collisions. Introduce the formula for momentum: $p = m\,v$ (momentum = mass × velocity). Discuss how Newton's Cradle demonstrates the conservation of momentum and energy. Briefly touch on how energy is transferred through the balls (kinetic and potential energy). **Exploration Activity (20 minutes)** In pairs, have students use a simple online simulation of a Newton's Cradle to manipulate the number of balls, their mass, and velocity. Ask them to predict outcomes based on different scenarios and compare their predictions with the simulation results. **Phase 2 - Design and Build (45 minutes)** **Review (5 minutes)** Recap the previous lesson's key points on momentum and energy conservation. Introduce the day's task: building a Newton's Cradle. **Design Planning (15 minutes)** Divide students into small groups. Distribute materials and worksheets. Guide students in planning their design, including calculating the ideal length of string, ensuring equal height for all balls, and considering the spacing. Emphasize the importance of precision in measurements and construction for accurate results. **Building the Cradle (25 minutes)** Students begin constructing their Newton's Cradle, following their design plans. Circulate the room to provide assistance and ensure safety and correct technique.

	Phase 3 – Testing, Analyzing, and Reflecting (45 minutes) **Finish Construction and Testing (15 minutes)** Students complete the construction of Newton's Cradle. They then test their cradles, observing the behavior when different numbers of balls are lifted and released. **Data Collection and Analysis (15 minutes)** Students record the results of their tests, including observations of momentum transfer, energy conservation, and any discrepancies. Using provided formulas, they calculate the theoretical outcomes and compare them to their observations. **Discussion and Reflection (15 minutes)** Groups present their findings to the class, discussing any differences between expected and actual results. Engage the class in a discussion on what factors could have influenced the results, such as friction, slight mass differences, or imperfect elasticity**.** **Phase 3 – Formula Graphs and Artistic Reflection (45 minutes)** **Visualization of the formulas that describe the experience** Use the online simulators to introduce students to the visualization of the data of the experiments. Link mathematic formulas with the graphical representation of different units in relation to time (e.g., speed/time, angle/time, etc.). **Artistic Reflection** Ask students to consider how the design of their Newton's Cradle could be made more aesthetically pleasing or artistic. They can submit sketches or photos of their cradle with suggested artistic modifications, explaining how these do not interfere with the cradle's function.
Assessment - Evaluation	*The teacher may evaluate the extend of the achievement of the learning objectives by observing students' active engagement and participation, their communication and collaboration during the team work, their understanding of Newton's Cradle through their analysis of the experiment and through ongoing discussion throughout the phases of the activity, and finally through evaluating students outcomes, the function of their Newton's Cradle.*
Presentation - Reporting - Sharing	*Students may take pictures and videos of their working Newton's Cradle and use them in their school portfolio or share them through their social media if that is locally endorsed by the school/school community.*
Extensions - Other Information	The teacher may ask students to explore the impact of changing the mass of the balls or using materials with different elastic properties, predicting and testing the outcomes. To do this, they may use software to create a virtual model of a Newton's Cradle with adjustable parameters to deepen understanding. Examples of existing online simulations can be found at the resources section of this Learning and Creativity Plan.

STEAME ACADEMY Prototype/Guide for Learning & Creativity Approach
Action Plan Formulation

Major steps in the STEAME learning approach:

STAGE I: Preparation by one or more teachers

1. Formulating initial thoughts on the thematic sectors/areas to be covered
2. Engaging the world of the wider environment / work / business / parents / society / environment/ ethics
3. Target Age Group of Students - Associating with the Official Curriculum - Setting Goals and Objectives
4. Organization of the tasks of the parties involved - Designation of Coordinator - Workplaces etc.

STAGE II: Action Plan Formulation (Steps 1-18)

Preparation (by teachers)

1. Relation to the Real World – Reflection
2. Incentive – Motivation
3. Formulation of a problem (possibly in stages or phases) resulting from the above

Development (by students) – Guidance & Evaluation (in 9-11, by teachers)

4. Background Creation - Search / Gather Information
5. Simplify the issue - Configure the problem with a limited number of requirements
6. Case Making - Designing - identifying materials for building / development / creation
7. Construction - Workflow - Implementation of projects
8. Observation-Experimentation - Initial Conclusions
9. Documentation - Searching Thematic Areas (AI fields) related to the subject under study – Explanation based on Existing Theories and / or Empirical Results
10. Gathering of results / information based on points 7, 8, 9
11. First group presentation by students

Configuration & Results (by students) – Guidance & Evaluation (by teachers)

12. Configure STEAME models to describe / represent / illustrate the results
13. Studying the results in 9 and drawing conclusions, using 12
14. Applications in Everyday Life - Suggestions for Developing 9 (Entrepreneurship - SIL Days)

Review (by teachers)

15. Review the problem and review it under more demanding conditions

Project Completion (by students) – Guidance & Evaluation (by teachers)

16. Repeat steps 5 through 11 with additional or new requirements as formulated in 15
17. Investigation - Case Studies - Expansion - New Theories - Testing New Conclusions

18. Presentation of Conclusions - Communication Tactics.

STAGE III: STEAME ACADEMY Actions and Cooperation in Creative Projects for school students

Title of Project: _____
Brief Description/Outline of Organizational Arrangements / Responsibilities for Action

STAGE	**Activities/Steps** Teacher 1(T1) Cooperation with T2 and student guidance	**Activities /Steps** **By Students** Age Group: ____	**Activities /Steps** Teacher 2 (T2) Cooperation with T1 and student guidance
A	Preparation of steps 1,2,3		Cooperation in step 3
B	Guidance in step 9	4,5,6,7,8,9,10	Support guidance in step 9
C	Creative Evaluation	11	Creative Evaluation
D	Guidance	12	Guidance
E	Guidance	13 (9+12)	Guidance
F	Organization (SIL) STEAME in Life	14 Meeting with Business representatives	Organization (SIL) STEAME in Life
G	Preparation of step 15		Cooperation in step 15
H	Guidance	16 (repetition 5-11)	Support Guidance
I	Guidance	17	Support Guidance
K	Creative Evaluation	18	Creative Evaluation