STEAME

HANDBOOK OF STEAME LEARNING & CREATIVITY PLANS

VOLUME 1
ENGLISH

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Guidelines for Developing and Implementing STEAME Schools

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INTRODUCTION

This handbook, supporting the "Guidelines for STEAME Activities in Schools for two Age Groups", is a collection of all the Learning and Creativity plans developed for the purpose of implementing STEAME (Science, Technology, Engineering, Arts, Mathematics and Entrepreneurship) activities. These Learning and Creativity plans are designed for STEAME subjects in two main categories: age level 12-15 (Grades 7-9) and age level 15-18 (Grades 10-12).

The main target groups of the Handbook of STEAME Learning and Creativity Plans, VOLUME 1 - ENGLISH, are teachers and educational leaders in European Schools. Furthermore, students will benefit from the implementation of these learning and creativity plans as part of the innovative educational transformation.

Introduction to the STEAME Learning and Creativity Plans

The STEAME Learning and Creativity (L&C) plans, developed by the STEAME project, aim to provide teachers with the information and resources needed to implement a STEAME lesson. The L&C Plans consist of the following five sections:

1. Overview
2. STEAME Framework
3. Objectives and Methodologies
4. Preparation and Means
5. Implementation

A brief description of the above five sections follows:

1. Overview of the L&C Plan

The section contains the general information of the L&C plan, such as:

- the related subjects (S-T-E-A-M-E) and the title of the STEAME project
- the driving question or topic;
- the ages and the grades
- the duration, the timeline, the number of activities and the curriculum alignment of the L&C plan
- a brief description of the project and/or learning activities related with objectives.

2. STEAME Framework

The section makes a direct relation to the STEAME framework. Contains the following 3 sub-sessions:

- *Teachers' Cooperation*: Teacher 1 cooperation with Teacher 2 and formulation of students' guidance
- *STEAME in Life (SiL) Organization*: Meeting with business representatives, Entrepreneurship - STEAME in Life (SiL) Days.
- *Action Plan Formulation*: Reference to the Stages and the Steps of the STEAME Framework (Action Plan Formulation)

3. Objectives and Methodologies

In this section describes the learning goals and objectives, the learning outcomes and results, the prior knowledge and prerequisites of learners, the motivation, methodology, strategies, etc. Contains the following 4 sub-sessions:

- *Learning Goals and Objectives*: Identification of goals or objectives using appropriate verbs, related or corresponding to competences (knowledge – skills - values), what learner be able to do after the project.
- *Learning Outcomes and expected Results*: Definition of Learning Outcomes using action verbs, expected results as any kind of deliverables or "artifacts".
- *Prior Knowledge and Prerequisites*: Prior experiences, knowledge and skills do the learners bring with them to this learning experience.
- *Motivation, Methodology, Strategies, Scaffolds*: Teaching strategies, approaches, methods, and/or techniques for achieving learning objectives and outputs (project-based, inquiry-based, problem-based, gamification etc.), instruction differentiation for students' needs (learning styles, multi-modal representations, roles to students etc.), active students' engagement, individual-team-classroom work, scaffolding techniques, etc.

4. Preparation and Means

This is the section that describes the preparation needed, the learning space setting, the resources, tools, etc. Contains the following 3 sub-sessions:

- *Preparation, Space Setting, Troubleshooting Tips*: Procedures, spaces, and material preparation, setting in classroom, outdoor activity, computer lab etc.
- *Resources, Tools, Material, Attachments, Equipment*: Instructional sources and digital material with the related references needed for the implementation of the learning plan.
- *Safety and Health*

5. Implementation

This section describes a complete approach to implement the L&C plan by listing the activities and procedures of the learning process, assessment and evaluation methods, presentation of the learning outcomes, etc. Contains the following 4 sub-sessions:

- *Instructional Activities, Procedures, Reflections*: Brief and comprehensive description of the creative activities, tasks, or learning experiences (individual-team-classroom working), Engagement and active participation through hands-on practices, Students' feedback and reflection on their thinking, process, or learning, Monitoring students' learning and progress measuring.
- *Evaluation - Assessment*: Assessment and formative evaluation processes and rubrics to measure the student's ability to perform what was described in the objectives.
- *Presentation - Reporting - Sharing*: Documents, outputs, artifacts, products produced by the students with references, web links etc., for sharing to media.
- *Extensions - Other Information*

LEARNING & CREATIVITY PLAN (L&C PLAN): STEAME in the work of entrepreneurs, scientists, artists

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☒	☐	☒	☐	☒

1. Overview			
Title	Projects for development of soft skills		
Driving Question or Topic	How do I conduct research, do analysis and summarize results in presentations and videos?		
Ages, Grades, …	**Ages 14-16**	**8th-9th grade**	
Duration, Timeline, Activities	24 learning hours	36*40 minutes	1 project/team
Curriculum Alignment	Personal development and IT classes in 8th and 9th grades		
Contributors, Partners			
Abstract - Synopsis	Students are divided in teams of 5-6 in their classes of Personal development and do research on topics related to Science, education, arts, business, digital technologies. All teams go through three main phases in one school year – between October and June: do desktop research and analyze information; conduct interviews with matter experts; prepare final presentation with a video on the topic to present to their peers at school. The teams and topics are assigned by the main teacher of the subject Personal development.		
References, Acknowledgements			
2. STEAME Framework			
Teachers' Cooperation	**Teacher 1** is the main teacher – in Personal development (soft skills) and/or Psychology/Philisophy or any other related subject who works in cooperation with the teachers: in Science and IT, Technology (IT, Computer Science). T1 provides the workplan, gives the foundational knowledge to students and assign main tasks for all teams starting with the division of teams and assigning one topic to each one of them: topics can vary, e.g.: Digital innovation, Innovation in education, Theater, Cinematography, Climate change, Innovative business, etc.		
STEAME in Life (SiL) Organization	**Teacher 2 is in Science – Chemistry, Biology, Physics.** Teaching scientific elements and topics and guidelines for students how to conduct scientific research, bibliography quotations, **references**, credible sources of information. T2 supports the project work with questions and particular tasks aligned with the main plan and workflow provided by T1. S/he assists with guidelines and ideas about potential interviewees – e.g. academic professors, scientists, other experts.		

	Teacher 3 is in Computer science/IT T3 works with the student teams to prepare their presentations and videos from technical point of view – provide guidelines about the existing tools, software, approaches – PowerPoint, Google slides, Prezi, Storyboardthat, video making tools, comix creation tools, digital storytelling and other tools.
Action Plan Formulation	**Stage 1** is **preparatory** actions by the teachers who work together led by the main teacher T1 who develops sample workplan with tasks, deadlines and topics aligned according to the curriculum of 8th and 9th grades. At this stage the assessment methodology is also developed – criteria and way of assessing students' work including self-assessment. Students are divided into teams and each one has a specific topic to research and analyze. **Stage 2** is the **implementation** when students start their work with introduction to the topics and all teachers work in their classes and online to mentor the students with specific questions. Throughout the classes students research and analyze the topics to get further clarification. **Stage 3** is **finalization** when all teams prepare their final presentations in the Computer science/IT classes and Personal development classes. **Stage 4 is evaluation** of the work. Each teacher follows the aligned evaluation methodology, i.e. evaluates the teamwork, the research and knowledge, the presentation and communication skills of students. Teachers in English language could also participate to evaluate the English language skills.
3. Objectives and Methodologies	
Learning Goals and Objectives	Upon completion of the class students should **know**: - How to conduct research, draw insights, analyze data - What are soft/non-technical skills - What project work and how to lead and implement it - Main terminology and key theoretical concepts in different topics They should **be able to** - Work in teams - Lead a team - Cooperate with their teachers in the relationship mentor-mentee - Conduct scientific research - Provide references - Conduct interviews - Arrange meetings, incl., planning the meeting - Business communication - Analyze data and prepare diagrams, graphs, Excel tables, etc. - Prepare presentations and videos - Apply creativity and generate new ideas - Communicate in the team and in front of an audience

Learning Outcomes and expected Results	Expected **results**: - Presentations with storytelling elements/videos/comix, etc. - Analysis and research results - Final conclusions - Conduction of interviews - Real application of the topics taught in their science classes
Prior Knowledge and Prerequisites	IT – Excel, presentation skills with PowerPoint, work with MS office, research and analysis.
Motivation, Methodology, Strategies, Scaffolds	The main differentiator in this Plan is the new subject taught at school – Personal development/soft skills development and the new role of teachers T2-T3 who guide and support the student teams on their work. Other approaches applied in the process are project- and inquiry-based learning. Under the new conditions of Covid-19 it can be easily adapted and be implemented as blended learning with flipped learning elements. This is another innovative approach, used in the project which is a type of blended learning where students are introduced to content at home and practice working through it at school. This is the reverse of the more common practice of introducing new content at school, then assigning homework and/or project to be completed by the students independently at home[1]. The plan allows individual work by each student when doing their research as the team leader divides the topic into sub-topics for each team member, then data analysis and preparation and organization of interviews for primary research followed by preparation of team presentations, video making, etc. It is a multi-modal approach and allows flexibility based on the student's learning style. The key success factor is for students to work on teams and be guided in the process in their classes and then work after school and do homework based on the main phases and elements of the projects and topics. Topics can be provided by the teachers and/or chosen by the teams. Team formation is good to be done based on various activities, personality tests, and define the leader of each team. The main teacher could work with the other teachers and/or alone on the team formation and topic definition. The topics are good to be broader in aspect so that students can narrow them until the end of the projects; e.g., Digital technologies and their future, Theatre, Arts now and then, Cinematography/Cinema/Movies, Education/Schools of the future, Innovative businesses, Museums of the future/The museum now and then, Tourism, The European Union, etc.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	There is one leading Teacher 1 who is in Personal development, Psychology, Philosophy or another related subject. T1 leads the process as the classes are organized around the student projects on specific topics aligned with the topics of studies in science, business, IT, Arts, and more general ones. There are classes taught in the Labs – science, arts, IT and students work there. All student teams should have at least one PC/laptop/desktop. In addition teachers provide also online support in the mentoring process according to a work plan. Their support is very important to guide students in the organization of interviews with external experts.

[1] https://www.teachthought.com/learning/the-definition-of-the-flipped-classroom/

Resources, Tools, Material, Attachments, Equipment	Tools to be used: - MS office – Word, Excel, PowerPoint, mind maps, analytical tools, - Citation Guide (https://libguides.dixie.edu/) - Digital storytelling: www.storyboardthat.com , www.powtoon.com , www.pixton.com, www.canva.com, etc. - Mind maps – www.miro.com, www.mindmup.com, www.mindmeister.com , venngage.com, etc. - communication and collaboration platform - Google Meet, Google Classroom, Zoom, Skype, etc. - e-learning platform – Google classroom, Moodle, other. - Data analysis tools
Safety and Health	

5. Implementation	
Instructional Activities, Procedures, Reflections	This Plan is developed around the school classes in the subjects Psychology, Personal development, Philosophy and other as the leading teacher/class. It covers: i. Information Technology ii. Science iii. Entrepreneurship iv. Art v. Presentation and communication skills vi. English language Teachers plan their activities on Google Calendar as part of the curriculum. T2-T3 follow their regular plans and includes examples and information and activities based on the field of research of the student teams. Students are actively engaged through hands-on experience and research conducted as homework assignments which can be discussed in class. The planned **24 learning hours** are based on a class of 40 minutes. All classes take place once a week with curriculum for 36 weeks in one school year. **The lead teacher, T1** is engaged in all his/her classes in one school year, i.e. 36 classes of 40 minutes each. - 4 hours introduction and preparation - followed by 12 hours – implementation - 4 classes work on presentations and video making - 4 hours final presentations and feedback sessions which are organized in the last two weeks of the school year and presented to a jury involving T1, T2, T3 ad English language teacher/s and all students from 8th and 9th grades. T2-T3 align their activities with the implementation including interview guidelines and how to analyze data, citation and bibliography, develop diagrams/graphs, presentations and online surveys (Google forms, Survey monkey, etc.). They support the teams and provide feedback for their work and final results.

Assessment - Evaluation	**The evaluation** is done on the following scale: - Self-assessment by team members (reflects the degree of critical thinking of each team member): from 0 to 100%, depending on the % of the total result achieved as an individual contribution to the project, fulfillment of tasks and activities, quality of results. It is based on peer evaluation and a common scale with the breakdown of the criteria provided by T1 and/or the team of teachers. - Team assessment by the team leader and the main teacher T1: (reflects the opinion of the team leader and the teacher about the work of each team member: from 0 to 100%, depending on the % of each contribution to the overall team result. - Jury rating (depending on the ranking): from 0 to 100% where the jury involves the participating teachers and other staff from the school and external experts, parents, school management, etc. They use common criteria including the soft skills/transversal skills – teamwork, presentation, creativity, content and analysis, digital storytelling, etc. - Assessment in English by the teacher/s for the English language of the presentations – this represents annual oral exam of students in their English classes - Bonus assessment (set at the teacher's discretion: from 0 to 100%). It can be given by the jury and the team of involved teachers for exceptional results, creative presentations, videos, etc.
Presentation - Reporting - Sharing	The presentation of the final results is done in front of: a jury of T1, T2, T3, peers in grades 8th and 9th, English teachers, the interviewees i.e., the external experts, parents. The main components of the presentations are: results from desktop research on the assigned topic, preparation of surveys and analysis of the results, at least one interview and a video (comics, mindmap or another tool for storytelling). Final conclusions and insights of the students is key success factor. Their own opinion and final recommendations is main focus so that they can analyze and provide opinion as essential skills.
Extensions - Other Information	All videos and presentations are uploaded on the school website and publications in social media. The projects can be further developed into case studies and students and teachers use them in their classes as learning materials and/or develop them further as projects.

STEAME 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:
   a. Research and analysis of data
   b. Presentation and communication skills, tools and methods
   c. Digital storytelling
   d. Preparation of online surveys and questionnaires
   e. Ethics of science

2. Engaging the world of the wider environment / work / business / parents / society / environment/ ethics
   The project- and inquiry-based learning is organized around student projects based on fined topics. The projects include research and data analysis, conducting interviews with matter experts – i.e. scientists, entrepreneurs, including local ones who can be involved in the process with interviews, brief presentations, discussions, participation and evaluation at the final presentations, etc.

3. Target Age Group of Students - Associating with the Official Curriculum - Setting Goals and Objectives
   The plan allows for involvement of students in Grades 8-9.

4. Organization of the tasks of the parties involved - Designation of Coordinator - Workplaces etc.
   T1 is the teacher in Personal development, Psychology, Philosophy. S/he provides the main case study/topic of work of the students and provides organizational guidance to the other teachers T2-T3 including strict workplan, tasks and monitoring. The classes can be done both online and in the classroom.
   T2 is teacher in Science – Biology, Chemistry, Physics – providing guidanca in terms of scientific research approach, methods, and provide knowledge about the specific examples, analysis of the work of the team assigned, including terminology and theory to be considered in the research; bibliography, citation rules and sources of credible information; guidance for analysis of data. Classes are conducted in the Science Lab.
   T3 is teacher in Computer science/IT fields. S/he prepares students how to analyze data, use Excel incl. formulas, diagrams/graphs, online surveys and questionnaires, etc. for statistical analysis and technical tools for development of presentations. T3 conducts classes in the Computer lab. The main task of T3 is to broaden the scope of presentation preparation beyond PowerPoint and Google slides and include also tools and software for video making.

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

Preparation (by teachers)

1. **Relation to the Real World – Reflection**
   Students are engaged in a project to apply their knowledge and skills in the real world examples around a common topic. Students work in team as in the real work environment.
2. **Incentive – Motivation**
   Students work in teams of 5-6. According to the criteria they can compete for the first place. They receive additional recognition by the T1 and/or the school as Certificates, extra-curricular work they conduct, etc. This L&C Plan allows for organization of final competition among all teams and/or different classes. Part of the work process is establishing contacts with successful and popular people in interviews and common discussions.
3. **Formulation of a problem (possibly in stages or phases) resulting from the above**
   Defining the main topic can be defined either by the group of teachers involved in this plan and/or by the students themselves. It is necessary to define criteria for selection – e.g., popularity, success, fields of interest, interesting facts, news, attractive trends for students,etc. It needs to be interesting and appealing to students and their age. At the same time the topic should be broad enough to allow division of sub-topics

and decision making by the teams to focus on narrow areas and trends within the broad topic – e.g., Innovative education can include research, selection and analysis of existing best practices among schools worldwide for innovative approaches and new ways of teaching including trends in Asia, North America, Europe, etc.
Students in general are more creative, they look for information online via different channels/platforms/media and can define the topic themselves, guided by their teachers.
This approach is suitable for 9th grade when they have some experience assuming they work on projects in 8th grade, too. This however should be a well-structured and guided process as they work in teams and the topic should allow division of sub-topics.

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

4. **Background Creation - Search / Gather Information**
   Students learn about the key success factors and concepts of work, incl. entrepreneurship and development in the specific fields. The main information is taught in class with the theoretical part, and then additional research is conducted online and via interviews. Some additional knowledge should be conveyed to them as well – e.g., how to contact people by email and/or phone, how to conduct interview, how to generate questionnaires for surveys, how to analyze data, what is an insight, etc.
   The role of all involved teachers is to teach them how to find the credible sources, too.
5. **Simplify the issue - Configure the problem with a limited number of requirements**
   After the initial definition of the main topic for the work of students the team guided by the T1 defines more specific sub-topics which are then assigned to each team member to start research and then combine all findings and summarize the information to start structuring and planning the presentations and the videos related to the topic – thus there are at least six teams of 5-6 students within the following aspects/sub-topics:
   - Science
   - Technology
   - Entrepreneurship

   The definition is broad enough to give freedom to students to develop their own research plan and main goals. The minimum requirements are related to the development of: online survey, desktop research, processing of the survey results, visualization of key findings and driving conclusions, interviews and making a video. All the above is structured in a presentation of two main parts – presentation with information and images, infographics, etc. and a story told in a video and/or comics.
6. **Case Making - Designing - identifying materials for building / development / creation**
   All student work in teams. T1 provides general guidance and introduction to the projects in the first 2-3 classes in subject Personal development. During the first five classes, teams should be formed by various tools like exercises, leadership style tests, personality tests, games, etc.
   Teams are formed by students and led by pre-defined leader who is their peer. Teachers 1-3 provide in-class and extracurricular distance (online) support. All teams follow the same working process but in different sub-fields: preparation on the subject, initial desktop research, online survey, analysis of survey results, further research, interviews, preparation of a presentation and video.
7. **Construction - Workflow - Implementation of projects**
   During the implementation of projects students follow their action plans approved by the main teacher T1. Each plan should include desktop research, collection and analysis of responses to online survey, key conclusions and insights presented in final team presentations. The main content is developed within the sub-area defined at the introduction and preparatory stage.
8. **Observation-Experimentation - Initial Conclusions**
   Student teams take part also in field trips organized by their teachers to a certain place, organisation, business – e.g., a company, theater, museum, cinema, etc. from professional point of view to observe how the process is organized, how people do their jobs, etc. In their classes they do different games, exercises, examples and theory. Students observe the processes and main concepts, then generate their own research which includes desktop research and online surveys. Depending on the topic defined it may include also conducting focus groups with peers and partners and parents. Final results are accumulated and visualized in a presentation and a video/story.
9. **Documentation - Searching Thematic Areas (STEAME fields) related to the subject under study – Explanation based on Existing Theories and / or Empirical Results**
   Students work together in their teams supported by T1, T2, T3 to validate the findings of the research. The models that are used for data analysis and main findings for the final presentations are aligned with the studies in 8th and 9th grades. Most common tools are based on MS Excel with focus on visual representation and use of graphs. In terms of science, simple experiments and knowledge are applied so that students can draw conclusions for the application in real life and work related to the topic they are working on – e.g., one of the popular and attractive topics is climate change and sustainable lifestyle.

The method of flipped classroom can be applied here as students work at home to review the theoretical content and then discuss in class and/or in their teams and ask relevant questions for further clarification and application in their projects.

10. **Gathering of results / information based on points 7, 8, 9**
    The main challenge in gathering accurate results is the source of information and the target groups for the online questionnaires that are distributed mainly in the existing networks in social media of students and mentors. Part of the process is the credibility of the source for the desktop research, which is covered by all teachers and mainly the ones who teach science. They provide guidance and monitor the process – e.g., what is the average age, area of expertise, geographic area, gender, etc.
11. **First group presentation by students**
    There are several presentations which mark the milestones in the work of the teams:
    - One for the findings of the desktop research
    - One based on the online surveys and the collection of answers, analysis and visualization.
    - Semi-final with information gathered by the interviews
    - Final two-part presentation with slides and video.

    Important part is the synthesis of all information and the ability to prepare graphs and comparisons – e.g. technologies and processes in the past and present days. Another important aspect is the impact on business development when working on topic related to business and entrepreneurship.

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

12. **Configure mathematics or other STEAME models to describe / represent / illustrate the results**
    Besides mathematical/statistical and scientific models, the presentations and analysis should include some financial analysis in terms of costs, revenue, profit and financial forecast. In their Math classes further clarification can be provided in terms of models for analysis and data bases.
13. **Studying the results in 9 and drawing conclusions, using 12**
    Students work actively in steps 4-9 but the role of mentors is critical for their argumentation, main conclusions and validity of results. The models that are applied should be relevant to their grade/age and experience. Main aspect of evaluation and success factor is their understanding for the real-life applications and practical use of the results. This is supported by the videos that they should prepare which proves how they perceive the knowledge gained in class.
14. **Applications in Everyday Life - Suggestions for Developing 9 (Entrepreneurship - SIL Days)**
    The research of topics can lead to direct application to other fields and businesses. Their projects can be leveraged and developed further in 10^{th} grade with work with business owners, managers and employees who provide their cases to be solved in the Entrepreneurship classes. The role of T1 here is important. The challenge can be related to finding the right challenger and/or organisation to work with. It is also key success factor to select the most suitable expert to interview.

Review (by teachers)

15. **Review the problem and review it under more demanding conditions**
    The main findings of students are structured in sub-areas and specific topics that they should identify to find the main problem and then provide recommendations. Teachers act as mentors and monitor if and how the topic is approached, researched and analyzed.

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**
    As described in step 14 the projects can be extended to draw conclusions and compare results with real companies and/or other organisations who agree to work with students on defined challenge to test new approaches and ideas, e.g. how the approaches of successful people/companies would affect their business.

18. **Presentation of Conclusions - Communication Tactics**
    The final presentations should consist of two main parts:
    - Presentation with key findings, recommendations and conclusions with graphs, images, etc.
    - Video telling a compelling story that complements the presentation and the main topic
    - Preparation of tables, spreadsheets, graphs, etc. to represent analysis of answers from the online questionnaires.
    - Use of social media and e-learning platforms for communication with the teachers and in the teams.

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

Brief Description/Outline of Organizational Arrangements / Responsibilities for Action

STAGE	**Activities/Steps** Teacher 1(T1) Cooperation with T2-T3 and student guidance	**Activities /Steps** **By Students** Age Group: 8th - 9th grade (13-15 years old)	**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 experts	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

LEARNING & CREATIVITY PLAN (L&C PLAN): Symmetry

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☒	☒	☒	☒	☐

1. Overview

Title	Symmetry
Driving Question or Topic	Identify symmetry in nature and explore its mathematical background and theory
Ages, Grades, …	Ages: 13-15 7-9 grades
Duration, Timeline, Activities	4 learning units, 8 hours 4*90 minutes 4 activities
Curriculum Alignment	Mathematics, Arts, Physics, Sciences
Contributors, Partners	
Abstract - Synopsis	Students are encouraged to find examples of symmetry in nature. Examples can be found in living organisms, architecture, music, physics and chemistry. Inductive reasoning is used to derive theoretical foundations of symmetry in mathematics.
References,	Rochelle Lueders: Symmetry from nature to the Classroom, https://www.bemidjistate.edu/academics/honors/symmetry-from-nature-to-the-classroom-lueders-rochelle/
Acknowledgements	none

2. STEAME Framework

Teachers' Cooperation	Teacher 1 (T1) – mathematics A3: Collects natural and abstract models found and leads discussions towards identifying their mathematical models and deriving the true nature of symmetry. A4: Explains mathematical models and explores their symmetries in a formal way. Teacher 2 (T2) – sciences: physics, chemistry A1: Leads discussion in class or during a field visit of surrounding symmetrical objects. Once line symmetry is identified, encourages discussion of space symmetry. Explains appearances of crystals in nature and human made. Teacher 3 (T3) – arts or language A2: Discusses symmetries in literature, music, architecture, painting. Provides examples and non-examples. The teachers can work together in arbitrary configuration or can teach their parts individually. Activities A1 and A2 can be carried out in arbitrary order.
STEAME in Life (SiL) Organization	Working with examples, field visit: architecture, painting gallery, jewelry shop. Making explicit measurements of natural objects.
Action Plan Formulation	There are 4 activities involved. A1 and A2 are interchangeable. A3 and A4 are interchangeable as well. They serve as the sum-up of the plan.

3. Objectives and Methodologies

Learning Goals and Objectives	Completing the L&C Plan, students will • Understand the meaning of symmetry; • Distinguish and name various basic types of symmetry; • Name symmetric patterns present in the nature; • Comprehend symmetry role in arts and literature; • Be able to present results of the project in written and oral form.

Learning Outcomes and expected Results	Students will be able to • Remember definition of symmetry and basics of their classification. • Understand role of symmetry in everyday live, arts and physical systems. • Apply gained information towards versification of the presence of symmetry in new situations and objects. • Tell difference between less and more symmetry. • Generalize gained knowledge to other concepts, e.g. similarity.
Prior Knowledge and Prerequisites	This L&C Plan does not require any prior knowledge. The central concept of symmetry will be explained from the scratch and illustrated with everyday examples.
Motivation, Methodology, Strategies, Scaffolds	Students shall comprehend real live roots of an important mathematical concept. They will be confronted with inductive method in science which starts with collecting data and seeks for an abstract generalization, theory. Students may discuss issues such as: is the symmetry understanding learned or are we born with this concept. Why is the linear symmetry the most common, etc. The goals of the L&C Plan can be achieved with an inquiry-based, an active learning that starts posing questions, problems and scenarios, or project-based approach, e.g., an in-depth project on finding symmetry in architectonical objects in the given area or even in the school itself. Supervision and light guidance of discussions is required throughout the project.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	The L&C should start with identifications of symmetry in the real world. This can be achieved in the classroom and outside of it. The discussion can be triggered by using a mirror. A mirror can be replaced by a smartphone with a camera facing its user switched on. One can multiply the effect facing two cameras and discuss why facing three cameras is not possible. Axial and planar symmetries are the easiest to identify. Then one can search for more complex symmetries and objects having high number of symmetries (even infinitely many, e.g. ideal mathematical objects such as a circle, a line, a torus etc.). Theoretical, mathematical framework should be taught in the classroom.
Resources, Tools, Material, Attachments, Equipment	It is possible to use objects naturally creating symmetry, e.g., mirrors, cameras. Pictures of symmetric object might be helpful. One can consider natural crystals and go to platonic solids and their symmetries. Possible diversion here is to let students grow their own crystals at home. There are instructions available online, which explain how this can be done effectively, e.g., https://www.youtube.com/watch?v=kKLga-8IMiY Inspirations for symmetry in the literature can be found here: https://www.sciencedirect.com/science/article/pii/0898122186901513 Symmetries in music are considered here: http://www.mi.sanu.ac.rs/vismath/visbook/apagyi/index.html Nice introduction to symmetry in the architecture, already organized in form of a lesson is available here: http://www.mi.sanu.ac.rs/vismath/visbook/apagyi/index.html Additional material is presented here: https://www.mi.sanu.ac.rs/vismath/kim/index.html
Safety and Health	There are no particular safety measures required by this L&C Plan.
5. Implementation	
Instructional Activities, Procedures, Reflections	This L&C Plan requires 4 units, 90 minutes each. It can begin either with T2 or T3 explaining symmetry in the real world or in the world of arts. T2 seeks with students' examples of symmetry in the real world, collects them and classifies types of encountered symmetry. (2 hours) T3 provides initial examples of symmetry in arts. Most likely the students will come up with examples in painting, sculpture and architecture first. It is less obvious to come up with examples in the literature and the music and this might require some instruction. (2 hours)

	T1 provides theoretical, mathematical background for the concept of symmetry. More importantly, T1 explains how examples from the real life are abstracted to the ideal world of mathematics. This provides opportunity to recall similar process for numbers (e.g. passing from concrete 2 cars to the abstract number 2). Some classification of planar and/or special symmetries should finish the course. (4 hours)
Assessment - Evaluation	Each activity can be accompanied by quick tests checking the comprehension of discussed concepts and examples. A possible way to test is to use a hand-out with a picture exhibiting a number of symmetries and asking to identify them. A funnier way to test, which increases considerably, the focus of students is by peer questions with immediate presentation of results using, e.g., https://pingo.coactum.de/ query tool. If prepared well, one can the opportunity to discuss the Gauss curve and its symmetry https://www.sciencedirect.com/topics/engineering/gaussian-curve At the end students should complete a short (5-10 minutes) multiple choice test, which can be carried out using electronic devices.
Presentation - Reporting - Sharing	Students might be required to collect examples of symmetric objects. If they come from real world they can create an exhibition, if they have only pictures of them, they can create a gallery. It is important that some examples come in the form hands on rather than digital.
Extensions - Other Information	A more general concept than symmetry is similarity. This is, in a sense, symmetry with a scale. Or just a scale. Again multiple examples are present in the real world and can motivate passage to abstract approaches.

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

Major steps in the STEAME learning approach:

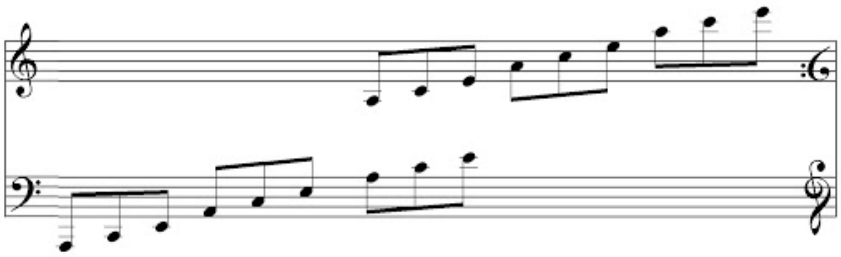
STAGE I: Preparation by one or more teachers

1. Formulating initial thoughts on the thematic sectors/areas to be covered
    - Symmetry and its presence in world and science;
    - Collecting initial examples;
    - Discussing approach to the problem in the presence of students.
2. Engaging the world of the wider environment / work / business / parents / society / environment/ ethics
    - Universality of abstract concepts. Inclusive character of science. Is there a good-evil symmetry?
3. Target Age Group of Students - Associating with the Official Curriculum - Setting Goals and Objectives
    - Can be worked out with students of grades 7-9.
    - Association to regular Curriculum should be discussed in any specific given case.
    - For Goals and Objectives see part 3 of the L&C.
4. Organization of the tasks of the parties involved - Designation of Coordinator - Workplaces etc.
    - Teacher 2 of sciences (physics, chemistry, geography, biology)
      Seeks with students examples of symmetry in the real world.
      This can be supported by mobile devices use. Can visit laboratory to inspect e.g. structure of crystals. Can visit architecture bureau. Can go out and seek symmetries in trees, everyday use devices etc. Can be taught also in the classroom without hands-on approach.
    - Teacher 3 of arts or language
      Presents initial examples of symmetries in arts and literature. Encourages students to come up with their own examples. Evaluates examples presented. Encourages discussion but tries not to lead it. Can be taught in a classroom, art gallery, exhibition etc.
    - Teacher 1 of mathematics
      Initiates discussion of underlying principles of symmetry encountered in lessons with T2 and T3. Provides guidelines for the principle of abstraction. This can be illustrated with examples such as the concept of a number, the concept of a segment, triangle, circle. Makes tights to philosophical ideas of Plato and his followers.

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

Preparation (by teachers)

1. **Relation to the Real World – Reflection**
    - Real world is full of symmetries. Identify examples. Pictures below present two objects exhibiting symmetry: Pentagon building and a music passage.



2. **Incentive – Motivation**
    - Explore basic concepts of the universe.
3. **Formulation of a problem (possibly in stages or phases) resulting from the above**
    - Based on a large series of collected examples, the idea is to pass to the abstract concept of symmetry.
      Apart of working with this specific concept, students should be exposed to the process of abstraction.

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

4. **Background Creation - Search / Gather Information**
    - Students create a large collection of symmetries ranging from objects in everyday life. Possible examples are: spoons, glasses, cloths. Passing to objects in wide understood arts, including architecture, painting, music, literature and coming to examples in sciences like crystals and galaxies.
5. **Simplify the issue - Configure the problem with a limited number of requirements**
    - Rather than simplify students should think towards properties joining all observed symmetries. In particular determine their number in specific cases.
6. **Case Making - Designing - identifying materials for building / development / creation**
    - Does not apply.
7. **Construction - Workflow - Implementation of projects**
    - Students can work in groups discussing and enhancing gathered sets of examples e.g. in the architecture and other rough groups.
8. **Observation-Experimentation - Initial Conclusions**
    - Students should identify what various categories of examples have in common.
9. **Documentation - Searching Thematic Areas (STEAME fields) related to the subject under study – Explanation based on Existing Theories and / or Empirical Results**
    - Students should become aware of symmetry presence in engineering objects, in arts, in mathematics, sciences, arts and even in economy discussing concepts of debts and investments.
10. **Gathering of results / information based on points 7, 8, 9**
    - Results should be gathered and prepared for presentation.
11. **First group presentation by students**
    - Results of working groups are presented and discussed with peers.

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

12. **Configure mathematics or other STEAME models to describe / represent / illustrate the results**
    - Collected examples can be presented e.g. in a form of a booklet with their depictions, a gallery, an internet collection etc.
13. **Studying the results in 9 and drawing conclusions, using 12**
    - Students are encouraged to draw conclusions on the abstract concept of symmetry.
14. **Applications in Everyday Life - Suggestions for Developing 9 (Entrepreneurship - SIL Days)**
    - Does not apply.

Review (by teachers)

15. **Review the problem and review it under more demanding conditions**
    - The concept of symmetry in mathematics is presented and analyzed. One can attempt to classify symmetries if the group works well. Symmetries focus on geometry, but this should include graphs of functions and numbers.

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.**
    - An output of the project should be a writing explaining what was done. It should mention some examples, explain the passage to the abstract concept and conclude with rigorous mathematical statements and formulations.

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

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

LEARNING & CREATIVITY PLAN (L&C PLAN):

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☐	☒	☐	☒	☒

1. Overview

Title Driving Question or Topic	An Educational Museum in our city! • A monitoring plan of an under construction Educational Museum, using security cameras of maximum efficiency that cost less or equal to €15,000.00. • What is the minimum number of security cameras needed for the museum, so that all parts could be monitored? • Where the cameras should be placed in order to offer the maximum level of security?
Ages, Grades, …	*Students's age 13-16* *Grades: 7-10*
Duration, Timeline, Activities	*12X45 muinutes*
Curriculum Alignment Contributors, Partners	Mathematics (Geometry, Algebra), Physics (Optic), Engineering, Economics
Abstract - Synopsis	Students study the polygon floor plan of the Educational Museum that is going to be built in their city. They try to place the minimum number of security cameras needed, so that the full area can be monitored. Within the budget of 15.000,00€, students are asked to research security options on the internet in order to propose the most effective plan (economical, practical and sufficient). They, also, develop a model of the museum, simulating the security cameras with colored LED lamps.
References, Acknowledgements	

2. STEAME Framework

Teachers' Cooperation	• Teacher 1: Mathematics (T1) T1 is the main teacher who provides the scenario and the work plan of the project. T1 supports students to their investigation with different types of polygons and their vertices. T1 works in cooperation with T2, T3 and T4. • Teacher 2: Physics (T2) T2 supports students with physics necessary knowledge as well with the simulation model. • Teacher 3: Engineer (T3) T3 is responsible for the model construction. T3 mentors and supports the teams with necessary knowledge and skills for developing the museum model. T3 works in cooperation with T2 to support teams while they are working with the colored LED lamps in order to guide students to find the minimum LED lamps (instead of cameras) needed for lightening the whole place, avoiding gaps or overlaps. T3 cooperates also with T1 for supporting students to generalize the relation between the maximum number of vertices of a polygon and the number of cameras needed for fully monitored. • Teacher 4: Economics/Entrepreneurship (T4)

	T4 supports and guide students in choosing the right cameras, keeping the purchase within the given money range.
STEAME in Life (SiL) Organization	*Security cameras are often used in almost all buildings in our modern society and therefore it is an issue that we face in our daily life. More specific, in line with the online shopping, students will deal with online data in order to choose products value for money. Furthermore, in their investigations, students will be involved in role plays of engineers, architectures and sellers, in order to successfully deal with their project.*
Action Plan Formulation	**STAGE I:** Preparation by T1 (steps 1-4) **STAGE II:** Action plan formulation by T1 in cooperation with T2 (steps 1-3) **STAGE II:** Action plan implementation (steps 4-5) (guidance by T1) **STAGE II:** Action plan implementation (steps 6-11) (guidance by T1 in cooperation by T2, T3, T4) **STAGE II:** Action plan implementation (steps 12-18) (guidance by T1)
3. Objectives and Methodologies	
Learning Goals and Objectives	Students should be able to: • Distinguish the characteristics of polygons. • Relate the number of vertices of a polygon to the number of security cameras required for effectively monitor a space. • Discover the general relationship of finding the maximum number of cameras that can be placed in an n-polygon (maximum number of cameras = $\lfloor \nu / 3 \rfloor$, where ν is the number of vertices and $\lfloor \nu / 3 \rfloor$ represents the largest integer less than or equal to $\nu / 3$) • Describe the model of linear propagation of light in homogeneous optical media and apply it in everyday situations. • Determine the polar diagram of the light emitted by a lamp and represent it graphically with photometric curves or three-dimensionally with a photometric solid. • To determine the minimum number of light sources that fully illuminate a given space, while minimizing overlaps. • Formulate hypotheses and apply procedures to check their hypotheses, changing different parameters. • Make data-based arguments to support or reject a proposition. • Decide effectively about the cost of a project.
Learning Outcomes and expected Results	Students will: • Make a presentation explaining the procedures applied for completing their work and justifying why the proposed solutions are optimal. • Write a detailed proposal to the Municipality about the installation of security cameras in the Museum. • Develop a model of the Museum and the security plan (simulation with colored lamps). • Present the purchase of buying security cameras, and justifications for their options. • Develop a formula for monitoring the inside and the outside of a space at the same time (the "Prison Yard Problem"[1]).
Prior Knowledge and Prerequisites	Concept / definition of a polygon (convex and non-convex) Concept / definition of the diagonal Concept of angle, types and name of angles in relation to their measure (zero, acute, right, obtuse, straight, reflex and complete angle) Measuring angles with the protractor Linear light propagation-polar light diagram Phenomena caused by linear light propagation (shadow) Global market perception (comparing prices and features)

Motivation, Methodology, Strategies, Scaffolds	The main approach of the project is the inquiry-based learning, where students are encouraged to investigate relations between the number of the vertices of a polygon and the number of security cameras needed to monitor the whole space inside the polygon. Students are actively involved into the tasks, facilitating their learning. They have the opportunity to deal with a real-life problem, to test ideas and to think creatively. They also make connections between different subject-matter knowledge.
4. Preparation and Means	
Preparation, Space Setting, Troubleshooting Tips	A real-life scenario about a museum security plan is the main context of the project. According to lesson activities, students could work individually, in pairs or in groups of 4-5 students. Tablets or laptops will be necessary for investigating the market. Furthermore, an engineering school lab could be utilized while students develop the museum model.
Resources, Tools, Material, Attachments, Equipment	Worksheets 1&2, LED lamps, materials for model construction (e.g pieces of thin wood, or thick paper, etc.)
Safety and Health	Safe use of cutting instruments while building the model of the museum.
5. Implementation	
Instructional Activities, Procedures, Reflections	**Activity 1:** (whole class discussion) A scenario about the effort of the Municipality to create an Education Museum in their city is presented to the students. In this museum, you can find reading and schoolbooks from all over the world, children's books and school supplies (notebooks, boxes, stationery, archives, supervision material, etc.). The architectural design of the museum has been selected through a competition and the Municipality is working on a security plan for monitoring and protecting the museum and its exhibits. Students study the floor plan of the museum (worksheet 1) and discuss about the use of security cameras, their possibilities as well as their limitations. **Activity 2:** (work in pairs) (a) Students search the internet for security camera's information and features and make a list about cameras specifications. They choose the type of the camera that is more suitable for placement in the various parts of the museum regarding their rotation and inclination. They use arguments to justify their choice. (b) Then, each pair works on the floor plan of the museum (non-convex polygon with n-sides, where each side corresponds to a wall of the three-dimensional space) (worksheet 1), trying to mark the places where security cameras should be placed, so that the space is fully monitored. **Activity 3:** (individual work and work in pairs) (a) For facilitating students work, we simplify the previous task. Students are asked to place the minimum number of cameras required in each of the nine given rooms (convex and non-convex polygons-worksheet 2) for full monitoring. For this activity, students consider that the cameras can be rotated 360° and infinite range, without losing image quality. In addition, the cameras may be placed on walls or ceilings, but the height of the camera is not concern because of the range of motion. Students use different colored pencils to show the different areas monitored by each camera. They are encouraged to avoid overlaps and gaps since the purpose of this activity is to find the minimum number of cameras needed to cover the entire space in each shape. Then, students work in pairs. They discuss their results and present them in plenary. (b) Working in pairs, they try to find a relationship between the number of vertices of the polygons and the number of security cameras required to fully monitor the space/shape. Then, they are asked to use this relation in order to find the maximum number of cameras required to monitor a polygon with given number of vertices. Students could list different pairs consisted of the number of the vertices of a polygon and the number of the required cameras. They are encouraged to design different polygons with the same number of vertices in

	order to identify patterns related to the number of the vertices of a polygon and the number of the required cameras (Maximum number of cameras = $\lfloor \nu/3 \rfloor$, where ν is the number of vertices and $\lfloor \nu/3 \rfloor$ represents the largest integer less than or equal to $\nu/3$). Students study the list and write their observations on worksheet 2. We expect them to realize that the problem of maximizing vertices is solved by maximizing the number of non-convex angles of a polygon. **Activity 4:** (develop a model-work in groups of 4-5 students) (a) Each group of students develop a model of the museum, using simple materials. Taking into account that the scale of the drawing in the worksheet 1 is 1: 100, each group is free to decide the scale of the model to be constructed. The height of the walls will be decided accordingly. In the model, students will place colored LED lamps to observe the points of space each lamp illuminates. The LED lamps simulate the security cameras. The aim of the task is to determine the minimum number of light sources required to fully illuminate the space, while minimizing overlaps. Colored lamps will facilitate this procedure. (b) Based on the model, students are asked to prepare a presentation in ppt, explaining the procedures they applied to complete their project and justifying why the solution or solutions they propose are optimal. **Activity 5:** Students do internet market research on the various options available for different types of security cameras. Given the maximum amount that can be spent for this purpose, they prepare a detailed proposal for the purchase of cameras, listing all the features of the cameras and the corresponding prices. They justify their choice or any alternative using appropriate arguments. The proposal and the costing will be addressed to the Municipality of their city. **Activity 6:** (a) Students are challenged to develop a formula for monitoring the inside and the outside space of the Education Museum at the same time. The expansion activity corresponds to the Prison Yard Problem. (b) Students design polygons-spaces that require a given minimum number of security cameras for fully monitoring. (c) Students explore different types of security cameras and point out how solutions change if we use static cameras or cameras with limited distance view.
Assessment-Evaluation	(a) Individual and group *formative assessment*, providing ongoing feedback during the development of the project. (b) Students are working backwards, designing polygons-spaces that require a given minimum number of security cameras for full monitoring.
Presentation - Reporting - Sharing	A presentation by each group takes place, explaining the procedures applied for completing their work and justifying why the proposed solutions are optimal. Also, a detailed proposal/report about the installation of the security cameras in the Museum could be forwarded to the Municipality. A developed model of the museum following by the security plan could be presented and described. Different colors of LED lamps could be used, simulating the security cameras plan.

Extensions - Other Information	(a) Students can expand the specific project by presenting how the internal and external space of the Education Museum can be monitored simultaneously. The expansion activity corresponds to the "Prison Yard Problem"[2]. (b) Students explore different types of security cameras and point out how solutions change if we use static cameras or cameras with limited distance view.

[2] *The prison yard problem*
(Füredi, Z., & Kleitman, D.J. (1994). The prison yard problem. *Combinatorica 14,* 287–300, https://doi.org/10.1007/BF01212977)
"The prison yard problem" is one of a family of guard problems, where one places guards at various points in or on a simple polygon (representing the walls of an enclosure) with the aim of covering (seeing) every point of the interior or exterior regions with at least one guard.

Given a polygon with *n* vertices whose sides are 'walls'. Guards, located at vertices, can see all directions, but cannot see beyond 'walls'. We prove that at most [*n*/2] guards suffice to see everywhere the whole plane. If the given polygon is not convex, then [*n*/2] suffice.

STEAME 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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

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

LEARNING & CREATIVITY PLAN (L&C PLAN): ALL EQUAL ALL DIFFERENT

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☒	☐	☐	☒	☐

1. Overview

Title	All equal, All different		
Driving Question or Topic	Does the length of the leaves of the Prunus pissardii plant follow a precise law of frequency distribution?		
Ages, Grades, …	AGES:15-16	9th - 10th grade	
Duration, Timeline, Activities	3 LEARNING HOURS	3*60 MINUTES	8 ACTIVITIES
Curriculum Alignment	Frequency distribution		
Contributors, Partners			
Abstract - Synopsis	The first 60-minute lesson is held by the science teacher who illustrates the kingdom of plants, the characteristics, the main divisions of plants and how to recognize them. In the second lesson (60 min) the class is divided into four groups and, in the school garden, the different groups look for and collect the Prunus pissardii plant (about 500 per group). Each group then proceeds to measure the collected leaves. In this phase, students learn to recognize and distinguish the different plant species. The collected data will then be included in an excel prospectus for their final processing and analysis based on the frequency distribution.		
References, Acknowledgements	• Scienze Biologiche Livello base – Autori: A. Sparvoli, F. Sparvoli, A. Zullini . Casa editrice Atlas (attività 1) • Matematica bianco multimediale 1 – Autori: Bergamini, Barozzi . Casa editrice: Zanichelli (attività 5 e 6)		

2. STEAME Framework*	
Teachers' Cooperation	1st Teacher: Sciences 2nd Teacher: Mathematics 3rd Teacher: Technology Specialist and/or Computer Scientist (The teachers of Technology and Mathematics can work together during the third lesson)
SiL organisation	A final poster will be published on the school's Facebook page
Action Plan Formulation	Stage I : preparation by 3 teachers Stage II : Action Plan formulation : The 3 teachers collaborate to the creation of the learning plan and define how relate the students' outcomes to the curriculum. They guide the students during the phases of the project, according to their specific competences (STEPS 1-2) and they collaborate for the final assessment step.
3. Objectives and Methodologies	
Learning Goals and Objectives	Students will have to define and calculate: ● The total length of each leaf ● The frequency distribution for each group and the total and they will ● Graphically represent the phenomenon
Learning Outcomes and expected Results	The project aims to demonstrate how, starting from a simple datum such as the length of a leaf, it is possible to define a much more complex concept linked to the distribution of frequencies and the demonstration of how, even if starting from different data, all these tend to approach an average value so as to form a curve called Gaussian. Students will then be led to reason about the usefulness of this scientific approach in the real world
Prior Knowledge and Prerequisites	Basic knowledge of mathematics and spreadsheets software
Motivation, Methodology, Strategies, Scaffolds	The main methodologies and techniques of the project are based on inquiry-based learning. In this way, students are encouraged to explore the material, organize the work, ask questions. Students are involved in conducting their own scientific research. Specifically, students learn by making their own research, instead of memorizing facts and content. This allows them to build knowledge through exploration, experience and discussion. As they explore this Learning Plan, students build critical thinking and communication skills.

4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	A shared calculation document will be the basic tool and with the use of spreadsheet document, children will make the appropriate calculations for the final frequency calculation. Laptops in the classroom, will be necessary for each group of students, in order to classify and sort the data . According to lesson activities students will work in groups of 4-5 students.
Resources, Tools, Material, Attachments, Equipment	• Textbook and youtube video for science and math concepts: https://youtu.be/QqCOA1OsXx4 http://web.booktab.it/BooktabWeb/ (libro matematica) • Excel sheet for calculating the frequency distribution • Kahoot: kahoot.it/ • Adobe Spark for the creation of the digital poster

5. Implementation	
Instructional Activities, Procedures, Reflections	The plan can be completed in three learning hours, the first hour with 3 activities related to the understanding and analyzing the kingdom of plants, and the following 2 hours of data collection and processing, concluding with the creation of graphs and their analysis. **STEP 1** **1. Brainstorming (35 minutes)** First of all, students are divided into groups of 4-5 persons. The teacher, through videos and images, illustrates the kingdom of plants and gives indications on how to recognize the different types of plants. https://youtu.be/QqCOA1OsXx4 Through the internet, the teacher shows images of Prunus pissardii **2. Playing with quizzes (10 minutes)** Working either individually or in small groups, the students play a Kahoot quiz-game prepared by the teacher. They try to answer multiple choice questions on the different types of plants  **3. Data search (15 minutes)** The students, in the school garden, look for the plant and collect the leaves for a total of about 500 per group.

STEP 2

4. Processing of collected data (60 minutes)

In the second lesson of computer technology, the students proceed, by groups, to divide the leaves by length and insert the data into an excel sheet created by them and organized by class of frequency.

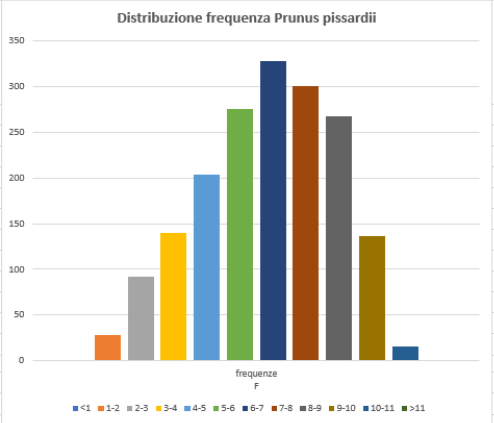
5. Meaning of some statistical concepts (20 minutes)

The mathematics teacher explains, with examples, the concepts of mode, mean and median.

6. Calculation of average data and creation of graphs (40 minutes)

Students then have to figure out how to complete the excel sheet previously created to find these values. They also need to create the final chart.

classi di frequenza	frequenze F	valore centrale V.C.	V.C. * F
<1	0	1	0
1-2	28	1,5	42
2-3	92	2,5	230
3-4	140	3,5	490
4-5	204	4,5	918
5-6	276	5,5	1518
6-7	328	6,5	2132
7-8	300	7,5	2250
8-9	268	8,5	2278
9-10	136	9,5	1292
10-11	16	10,5	168
>11	0	11	0
	1.788		11.318
Media	6,33		
Moda	6-7		



La gaussiana è una curva dalla classica forma a campana che ha un massimo intorno alla medie dei valori misurati. Nel nostro caso i valori misurati sono stati quelli della lunghezza delle foglie di un campione di 1788 preso dalla pianta prunus pissardii. Si può notare che la distribuzione di frequenza si avvicina abbastanza ad una distribuzione gaussiana.
Questo è avvalorato anche dal fatto che il valore medio calcolato è pari a circa 6,3 e anche la moda della distribuzione è relativa alla classe 6 - 7 . In una distribuzione gaussiana infatti moda, media e mediana coincidono.

7. Analysis of the result obtained (30 minutes)

The teacher makes a reflection on the result achieved by each group.

He offers students images of different frequency distributions and asks them to choose if there is an analogy with the results obtained with their research.

8. In-depth study, discussion and conclusion (30 minutes)

The teacher explains the meaning of the Gaussian curve; asks students to carry out a research to understand its use in the real world.

Assessment - Evaluation

- A self-assessment with immediate results, is the Kahoot game (activity 2).
- A group-assessment is the final research activity at the end of activities 7 and 8

In addition the teachers will monitor students' collaboration skills during the activities, their individual organizational skills and interaction with the group

Presentation - Reporting - Sharing

A presentation by each group takes place at the end of activity 8 (an additional 30 minute lesson), analyzing the cases found, Creating posters with Spark Adobe.

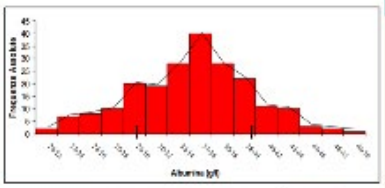
The poster will then be published on the school's Facebook page.

Tutti uguali tutti diversi

Il primo punto è quello che genera maggiori preoccupazioni; in realtà i parametri clinici si distribuiscono secondo curve a campana centrate attorno a una media; i range di riferimento cercano di indicare con buona probabilità quando si è di fronte a un individuo normalmente sano. Un po' come se io dicessi che gli italiani maschi sono alti da 165 a 185 cm: un soggetto alto 163 cm è comunque normale, mentre un soggetto adulto alto 140 cm è sicuramente affetto da nanismo.

GAUSSIANA

Figura 1 - Istogramma di frequenza della concentrazione sierica di albumina in 211 pazienti con cirrosi biliare primitiva



L'IMPORTANZA DI QUESTI CONCETTI

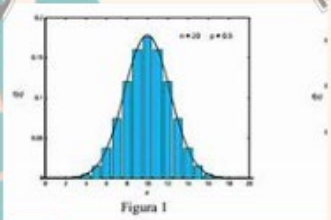


Figura 1

Supponiamo di considerare l'altezza degli italiani maschi. Analizziamo un campione di 1.000 soggetti. Probabilmente otterremmo una curva a campana, centrata attorno a una media, del tipo 174 cm di media con una "deviazione standard" di circa 20 cm, cioè il 95% dei soggetti analizzati sarebbe compreso fra 154 cm e 194 cm.

Adobe Spark

STEAME 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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

Brief Description/Outline of Organizational Arrangements / Responsibilities for Action

STAGE	**Activities/Steps** Teacher 1(T1) Cooperation with T2, T3 and student guidance	**Activities /Steps** **By Students** Age Group: 15-16	**Activities /Steps** Teacher 2 (T2) Cooperation with T1 ,T3 and student guidance	**Activities/ Steps** **Teacher 3 (T3)** Cooperation with T1 ,T2 and student guidance
A	Preparation of steps 1,2		Cooperation in Steps 1,2	Cooperation in Steps 1,2
B	Guidance in Act. 1-3	1.2.3.4.5.6.7.8	Guidance in Act. 5,6,7,8	Guidance in Act. 4,6
C	Creative Evaluation Act. 2	2,8	Creative Evaluation Act. 8	Creative evaluation Act. 8
F	Organization (SIL) STEAME in Life	Publication of poster on Facebook	Organization (SIL) STEAME in Life	Organization (SIL) STEAME in Life

LEARNING & CREATIVITY PLAN: A GUIDED TOUR

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☒	☐	☒	☒	☒

1. Overview			
Title	A GUIDED TOUR		
Driving Question or Topic	What I need to know about the place to visit and what resources I need		
Ages, Grades, …	AGES:12-14	6th - 8th grade	
Duration, Timeline, Activities	3 LEARNING HOURS	4*90 MINUTES	7 ACTIVITIES
Curriculum Alignment	Itinerary, cost estimates and basic knowledge of graphics		
Contributors, Partners			
Abstract - Synopsis	The project includes an initial phase with lessons by teachers who will give indications on the brochure to be made for the organization of the guided tour. Students will be divided into groups to search for the different information necessary to define the itinerary and the cost estimate. They will then have to calculate the price to charge to the participants. At the end they will be able to design a brochure with all the information.		
References, Acknowledgements			
2. STEAME Framework*			
Teachers' Cooperation	1st Teacher: Economy teacher 2nd Teacher: Art/Science teacher depending on the type of itinerary (The art teacher will be required to write the brochure)		
STEAME in Life (SiL) Organization	Meeting with a travel agent who explains students how to draw up an itinerary and a cost estimate and how to build a budget , meet with a graphic designer that		

	shows them how to make a brochure attractive, what strategies to use, such as what type of images and fonts to use. In addition to the indicated external partners you could involve: for the organization: people who work in the travel industry or in the organization of events like travel consultants, recreation guides or meeting and convention planners; to design the brochure: people who work in graphic business like art or industrial designers, advertising managers, page layout workers, drafters, web developers or multimedia artists.
Action Plan Formulation	[Preparation STEP A 1-3] by two teachers in collaboration Refers to the creation of the plan formulation **STAGE I**: Preparation by two teachers [Step B: activities 1-3], **STAGE II**: Action Plan/Learning Plan, by the two teachers in collaboration [Step B: activities 4-6] **STAGE II**: Action Plan Formulation [Development STEPS B and C: activities 4-7] Refers to the realization by the students of the four activities of the Learning Plan. **STAGE II**: Action Plan Formulation [STEP D: activity 7] Refers to the evaluation by the teachers [activity 7], and the presentation by the students of their results [activity 7].
3. Objectives and Methodologies	
Learning Goals and Objectives	At the end of the work students will understand the importance of planning and making cost estimates before organizing any activity.
Learning Outcomes and expected Results	At the end of the project, students are expected to understand that planning involves a long and detailed process. It is necessary that every activity is well defined in time and costs. They will learn that cost planning requires a great deal of attention in the definition of the necessary expenses to avoid unnecessary ones. They will then have to compare different estimates and choose the best not only in terms of cost but also quality. Finally, with the preparation of the brochure, they will understand how important the layout of the presentation is to find tour participants.
Prior Knowledge and Prerequisites	Basic knowledge of Mathematics, graphics and global market perception (comparing prices and features)

Motivation, Methodology, Strategies, Scaffolds	The main motivation that will drive students will be curiosity. They will have to try to know as much as possible the place to visit to define the activities to be practiced. In learning by doing, they will learn to search for necessary information themselves and to deepen their knowledge. Usually at school students learn from information given by third parties or by teachers and books. They will have to work in groups and divide the tasks because otherwise they would lack time to complete the work. They will experiment confrontation and discussion between peers in order to achieve a goal. They will then have to trust each other. In implementing the problem solving technique, they will be faced with the need to make choices and make decisions. They will also face the need to contain costs to reduce the budget and therefore will experience the scarcity of resources. At that age children often have parents who support them on any occasion. They will have the opportunity to show all their imagination and creativity in the graphic activities when writing the brochure. They will have the opportunity to show a finished product that attracts the attention of those who watch it and therefore to be proud of their contribution to its realization.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	Students will work mainly in the classroom even if divided into groups of 4-5. They will need internet-based tools to search for information in the first phase. They must also have a computer to do the calculations. In the phase of drafting the brochure instead, it will be essential the use of the computer lab with free basic graphical programs. In addition to this there will also be the need of material for color printing of the brochures.
Resources, Tools, Material, Attachments, Equipment	HOW-TO VIDEOS: https://study.com/academy/lesson/project-cost-management-planning-estimation.html https://www.intostudy.com/en/how-to-budget/travel GRAPHICS FREE PROGRAMS: https://inkscape.org/it/release/inkscape-1.0.1/ https://www.gimp.org/downloads/
Safety and Health	

5. Implementation

Instructional Activities, Procedures, Reflections

STAGE I

1st Activity 1st Lesson (1 hour)

It starts with the first Economy lesson where the teacher explains what a budget is. The teacher also explains how to make a forecast of the number of participants based on the statistics available to the school.

During the lesson, students watch a video about how to plan a tour and another one about the need of accurately estimating expenses.

They analyze the costs to be included and how to calculate the price to be paid to participants so as to be able to cover expenses.

2nd Activity 2nd Lesson (1 hour)

This lesson will be held with the Art or Science teacher depending on the type of tour they intend to plan.

If they decide for a cultural tour, the Art teacher shows the children the works and places to visit and explains the history.

If instead the students intend to make a naturalistic tour, it will be the Science teacher to give them indications on the biology of the place and on the arboreal species.

3rd Activity 3rd Lesson (1 hour)

The lesson starts with the meeting with the experts, travel agent and graphic designer, then, the Art teacher explains the students how to make a simple brochure and shows which graphics programs to use.

STAGE II

4th Activity

Brainstorming (30 minutes)

Students together with the teacher define the first draft of the program of itinerary. The teacher divides them into groups of 4-5 and assigns to each one a task. Alternatively everyone has to draw up a detailed part of the itinerary.

Itinerary writing (30 minutes)

Each group will detail their part of the itinerary referring to some examples found on the internet. They will indicate the precise time and place and make a brief description of each activity that will be carried out.

Cost definition (30 minutes)

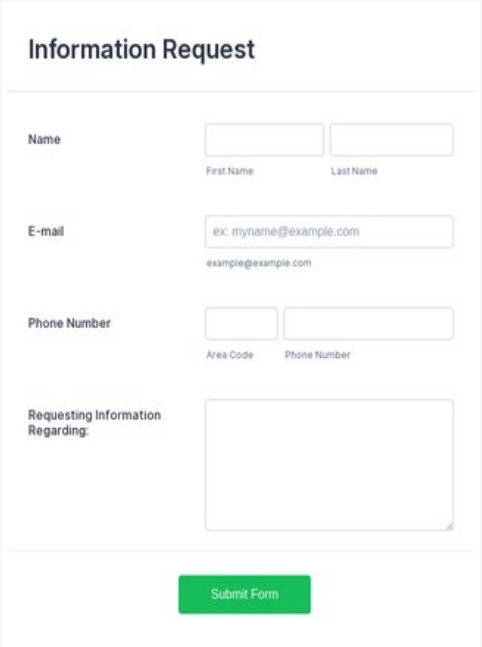
Each group will identify the planned expenses for the activities, defining them exactly and in detail in order to request estimates with the utmost precision. The costs will be necessary for the guide, for the entrance tickets and for the transport.

5th Activity

Call for tenders (90 minutes)

Consulting websites, the groups will characterize the possible service suppliers and will proceed to demand an estimate of expense for the activities they have planned.

Students may need to fill a written request similar to the one below. It will be necessary for them to be as precise as possible in the request. It may therefore require time.



6th Activity

Supplier selection (60 minutes)

Students will then proceed to the identification of the best estimate based on the price and the quality of the service offered.

Definition of the price to apply (30 minutes)

Once the estimates are collected, the general budget is defined.

Based on the estimated number of participants, the total cost is divided, taking into account a percentage of variability on the subscriptions. All these estimates are based on the work done in the first lesson with the economics teacher.

	7th Activity **Material collection (30 minutes)** The groups collect images, photos and documents about the places to visit. They then make a choice of the most significant and which can better attract the attention of possible participants. **Brochure composition (90 minutes)** The groups at this point meet to write the brochure also on the basis of models taken from the internet, as listed below. Then through the graphics programs that they will download, they insert the images and texts defined previously.  ESN PLOVDIV INTERNATIONAL EXCHANGE ERASMUS STUDENT NETWORK ONE DAY TRIP TO BACHKOVO MONASTERY – 04.03.2016 ESN Plovdiv wants to invite you to the spring excursion to Bachovo. We will see one of the biggest monasteries in Bulgaria. The Bachkovo Monastery archaically the Petritsoni Monastery or Monastery of the Mother of God Petritzonitissa in Bulgaria is an important monument of Christian architecture and one of the largest and oldest Eastern Orthodox monasteries in Europe. It is located on the right bank of the Chepelare River, 189 km from Sofia and 10 km south of Asenovgrad, and is directly subordinate to the Holy Synod of the Bulgarian Orthodox Church. The monastery is known and appreciated for the unique combination of Byzantine, Georgian and Bulgarian culture, united by the common faith. Program: 10:30 - departure from Plovdiv 11:20 - arrival in Bachkovo 11:30 - Examination of the monastery, the monastery ossuary and free time for souvenirs. 13:00 - Free time (90 min) 14:30 - Eco path in the forest (meeting in front of the bus) 15:00 - Ice breaking games (Jenny, Yana and Nasko)  One day trip to Doi Inthanon National Park, Thailand. Itinerary One of the most famous national parks of Thailand and the highest mountain in the country. 08.00 – 08.30 AM - Pick up at your hotel with an air-conditioned minibus. Get away from the busy town and travel along mountain road for about 1 hour. to the national park stopping at the "Vachirathan" falls. Head to the original "Karen & Mong" hill- tribe village (Hill Tribes market). Drive to "Sirithan" falls for Stop for lunch. Then go to "The Royal Project" the place for "The Western Horticulture plants" for 40-45 minutes. Visit "The King and Queen's Pagodas" built for their Golden Jubilee: very beautiful. Stay for 40-45 minutes. Head to "The Peak of Thailand" at 2,565 M. above sea level. Take a break, then "Trek through the Green Moisture Hill". 05.30 PM - Return to your hotel. Includes: A/C van, Lunch & drinking water, all admission fee, English speaking guide, Accident insurance, national park fee 300 Bht.pp. Price per person: 1,550 THB. pp. (Join Group) **Discount 100 Bht.pp. Recommonde' par "Le Guide du Routard and The Trotter guide book. TOUR DOSE NOT INCLUDES: All kind of drinks. Clothing: T- shirt, Short pants, Walking shoes, Socks, Swimming suit, Towel, Insect spray, Sun cream, Raincoat (in rain season), Money for your own use. Contact: Mr.Peter HP +66 81 884 2055, WhatApps:+66818842055
RD	The evaluation of the students will be carried out mainly on the efforts in the activity. Teachers will also assess teamwork and the ability to solve problems. An evaluation will then be given to the overall work, or the brochure in terms of graphics and integrity of the information. https://inkscape.org/it/release/inkscape-1.0.1/ https://www.gimp.org/downloads/
Presentation - Reporting - Sharing	The product of all this work is a brochure of the organization of a guided tour with indication of the full program of the day and the price for participation. The organization of the tour could become a fundamental yearly excursion for many students. Travel agencies could then use the brochure to present the tour to other school students in the territory.
Extensions - Other Information	Students could really do the guided tour accompanied by the teachers who helped them to organize it.

STEAME Prototype/Guide for Learning & Creativity Approach

Action Plan Formulation

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3. Target Age Group of Students - Associating with the Official Curriculum - Setting Goals and Objectives
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STAGE II: Action Plan Formulation (Steps 1-18)

Preparation (by teachers)

1. Relation to the Real World – Reflection
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18. Presentation of Conclusions - Communication Tactics.

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

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: 12-14	**Activities /Steps** Teacher 2 (T2)/possibly Teacher 3 (Science) Cooperation with T1 and student guidance
A	Preparation of step 1		Cooperation in step 1
B	Guidance in activities 1,4,5,6	4,5,6,7	Support guidance activities 2,3,7
C	Creative Evaluation 6	6,7	Creative Evaluation 7
D	Organization (SIL) STEAME in Life 1,3,7	1,3,7 Meeting/presentation to travel agent and graphic designer	3,7

LEARNING & CREATIVITY PLAN (L&C PLAN):

S	*T*	*Eng*	*A*	*M*	*Ent*
☐	☒	☐	☒	☐	☐

1. Overview	
Title	OPEN-AIR MUSEUM
Driving Question or Topic	How does art reflect the community? How does technology connect to art?
Ages, Grades, …	AGES: 13-14 Grade: 7-8
Duration, Timeline, Activities	15 hours 10 ACTIVITES
Curriculum Alignment	
Contributors, Partners	
Abstract - Synopsis	The project design includes the analysis of territorial and environmental realities through the search and picture taking of public art sites, the production of a virtual walking tour and the creation of original model sculptures with a public proposal to install them in various city sites. Through the exercise of competencies like creativity, cooperation and problem solving, students understand how their work can impact on the community and relate knowledge to the management of real life problems.
References, Acknowledgements	The plan is inspired to a project called "Kinetic Conundrum " **https://www.edutopia.org/video/anatomy-project-kinetic-conundrum**

2. STEAME Framework	
Teachers' Cooperation	1st Teacher: Art and /or social sciences 2nd Teacher: Technology Specialist and/or Computer Scientist
SiL Organization	A real meeting with local authorities members (town planning office) at the beginning of the project to check collaboration and at the end for the presentation of the results
Action Plan Formulation	**STAGE I**: Preparation by two teachers [STEPS 1-3], and **STAGE II**: Action Plan Formulation [Preparation STEPS 1-10]

	The two teachers collaborate to the creation of the learning plan. They define how to connect the project outcomes to the curriculum, they set project goals and, if necessary, they assess the teachers' competences for the project. The Technology teacher may build a model prototype with the aim to show students a possible result, but not for them to copy.
3. Objectives and Methodologies	
Learning Goals and Objectives	By the end of the L&C Plan, students will ● find the answer to the guiding questions and so they will know how art reflects the community and how technology connects to art as an expression of people and culture. ● Be able to verbalize the products made with the appropriate, specific terminology. ● Know and compare the different expressive techniques, traditional and multimedia ● Be able to operate intellectually and manually for an intentional and verifiable result as a synthesis of a cognitive, scientific process. ● Be able to identify simple elements and procedures present in complex processes and objects, allowing them to be reused in the implementation of different but conceptually similar processes. ● Be able to formulate hypotheses, detect and process data, evaluate results, compare phenomena attributable to the same model of communicating using the technical language correctly. ● Identify the type of artistic, cultural and environmental assets present in their territory
Learning Outcomes and expected Results	● After the project, learners will have a better knowledge of the artistic aspect of the area they live in and become more competent using new technologies to shape their achievements. The acquisition of knowledge and skills is achieved considering every technical fact and every production process that is not isolated, but in relation to other facts and processes, with the man who uses it and with the environment it is intended for. ● This procedure develops their critical mind and fosters their curiosity about the social environment and awareness of their creative abilities. Their communicative skills will be enhanced, as they will work in groups and be obliged to relate to the social context. ● The tangible results will be the virtual tour on Google maps and the model sculpture created.
Prior Knowledge and Prerequisites	● The basic structures of visual language ● The codes and compositional rules present in works of art and in multimedia communication (use resources also available from the Internet) ● Basic knowledge of how to place works of art in their respective historical environmental contexts ● Use of the most common technical terms relating to proceedings: units of measurement and calculation techniques; geometric design

	• The concept of relationship and proportion and basic concepts related to materials • Basic operational skills, in accordance with safety and accident prevention regulations • Tools and techniques for creative personal production: questionnaires and investigation tools • Representing and expressing what has been observed and one's personal experiences
Motivation, Methodology, Strategies, Scaffolds	The privileged methodological approach is the communicative-laboratorial one. A methodology of discovery and research in terms of lived experiences will be applied. Students' work is not reduced to manual skills - even if it includes them – but it is assumed as a fundamental didactic element. It has a formative value because motivated activities of a problematic type are favored. Motivating activities arise from the individual and collective needs. To achieve the objectives, the inductive method and the problem-solving methodology are used: concrete problem situations that arouse the interests of the students and take into account the technical concepts through reflections on the text, research activities, laboratory and operational processes. Within these methodologies, the design method is used, intended as a path that leads to the solution of a problem through technical analysis, direct or comparative observation and the realization of simple technical-operational activities aimed at acquiring skills and the consolidation of concepts.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	Tablets, laptops and IWB in the classroom (or a media lab), digital cameras or cell phones to take pictures will be necessary for students, in order to research the topics and develop their virtual city tour; art supplies , shop tools . According to lesson activities students could work individually, in pairs /groups or in plenary sessions. Other spaces: school auditorium or gym for the final event 1.Support material for phase 1 activities City/town videos https://www.youtube.com/results?search_query=city+tours+ Google maps application (my maps) https://www.google.com/maps/about/mymaps/ (application) https://www.youtube.com/watch?v=QIvxXUzc2U8 (tutorial on how to create a map) 2. Instructional videos and lesson plans for variuos types of sculpture building : https://www.youtube.com/results?search_query=how+to+create+kinetic+sculpture (Selection of videos)

	Kinetic Sculpture - Art-O-Motion - Lesson Plan - YouTube (PDF version of lesson plan : Layout 1 (ctfassets.net) Art-O-Motion 2 - Lesson Plan - YouTube (PDF version: art-o-motion-2-kinetic-sculpture.pdf (ctfassets.net) STEM At Home Episode #7: Building a kinetic sculpture - YouTube #stemathome - YouTube (Selection of ideas) Grade 10 Kinetic Sculptures - YouTube How to Make a Mobile - #1 Thing You Need to Know - YouTube Scale Model Trees / 9 Ways (How To Make) - YouTube Making Pinwheels from Aluminum Cans with Cardboard - YouTube 3. Worksheets for activities and assessment: group – work assessment sheet https://www.schrockguide.net/assessment-and-rubrics.html (a collection of multipurpose rubrics) https://www.slideshare.net/carlyrelf/grade-8-hivrubricnov2011 (Assessing a multimedia product) https://www.studentartguide.com/articles/how-to-analyze-an-artwork https://www.edutopia.org/pbl-assessment-resources *architectural analysis. PDF* *group self-assessment rubric.pdf* *Self-evaluation Chart.pdf* *edutopia-rubric.pdf*
Resources, Tools, Material, Attachments, Equipment *Safety and Health*	

5. Implementation

Instructional Activities, Procedures, Reflections	The plan can be completed in 3 main phases, the first phase (3 hours with 3 activities) relates to the research, analysis and understanding of existing landscape features ; the second phase (2 hours with 2 activities) is a transitional phase implying the creation of the first tangible product , the virtual tour and an interim

assessment session. The third phase (10 hours and 5 activities) culminated in the creation of students' own personal sculpture and connects the whole project to real life issues.

1. **Research and photograph public art sites (1 hour in class – 1 hour field work + 1 hour plenary session +writing activity)**

Activity 1: brainstorming /motivation and video analysis

Activity 2: field work

Activity 3: description writing

In the art class the teacher presents the project idea and the driving questions. Students are then presented with a video focusing on the architectural features of their city. They are encouraged to express their reactions on positive aspects they value and negative aspects they would want to improve. The teacher presents a selection of public art pieces/installations to study. Students are divided into groups of 3- 4 persons. Each group will work on 1 or 2 art pieces (depending on the size of the class and the pieces involved). The task is to go around the town and photographs the chosen installations. The students are given a worksheet to guide them in retrieving relevant information from the research and the direct observation of the artworks (more able students may be given a less structured task). The type of information collected will guide them later on in the project for the construction of their personal model structure. Here's a possible worksheet to be used.

Analysis of an architectural work: _____

Identification details:

Photo (insert an overall image of the structure)	Details: Author _____ Dating _____ Dimensions _____ Location _____

Technical analysis

Technique and materials (materials used and methods of processing them):
_____
_____

State of conservation (integrated work / damaged/ rebuilt)
_____
_____

Any restoration work done?
_____
_____

Stylistic analysis

Type (intended use)
_____
_____

Plan, elevation, section (analysis of the compositional and functional aspects and of the stylistic models of reference)
_____
_____

Lighting (typology and expressive function of the light sources)
_____
_____

Surface treatment and color (sharp/rounded/grooved/smooth/opaque/glossy edges…
_____
_____

History

History of studies (critical and interpretative events of the work over time)
_____
_____

Bibliography and sitography: according to the scheme: author, title
_____
_____

In the following session students will share the information they have found and, in groups write their own description of the pieces of art chosen, including relevant discoveries and personal impressions.

2. **Place information on Google maps to create a walking tour (2 hours)**

Activity 1: creation of multimedia product

Activity **2: assessment**

The descriptions and pictures are loaded on Google maps- my maps and all the different public art sites will be connected as a walking tour. Students create a virtual tour, by which clicking on the piece of art on the map, it will show the information that they have found and written about. The students and teachers evaluate the quality of the virtual product created by comparing it to similar existing products and by testing its useability with other students, teachers and parents.

3.Writing a proposal for the installation of an original artifact (30 minutes)

Activity 1: letter writing

In the language arts class, (plenary session) students write a letter to city officials with proposals for the installation of their original works that they are going to build. In this way student will relate to the community needs, show artistic appreciation of their realities and show awareness for the improvement of the city landscape,

4.Designing and building a model of an artifact/ sculpture (5 hours + 30 minutes ideation as homework)

Activity 1: model project design

Activity 2: sculpture building

In the Tech class students design their original model (first given as a home assignment and later finalised in class). They then build it. The rationale behind the activity is that students have fun and learn to be creative; they get to think about something, and in the creation process are encouraged to experiment and to develop problem solving abilities (tinkering). The activity is carried out in pairs. The materials used will be easily available even in the home: boxes, glasses, sheets of paper, pieces of wood, metal wires, plastic wrappers. Several techniques and materials can be employed to build different kinds of sculptures, according to the time available, to the experience of the teacher guiding the students and to the level of ability of the students themselves. The videos and material provided in the ‘preparation section’ of this plan can be useful to gather ideas and procedures for different kinds of work.

	5. Preparing material for presentation (1 class hour + 1 hour homework) **Activity 1: written report/leaflet** After completing their work, the students will prepare a written report / leaflet with pictures and technical specifications and detailed description of their sculpture to go along with the oral public presentation . **6. Display model and discuss work at a public event. (2 hours)** **Activity 1: model sculptures display** The students will display their model sculptures, describe them with the help of the leaflets created and discuss their installation proposals with parents and members of the community. On the occasion they will answer questions on how they made their sculpture, how the sculpture works and why they chose to make that particular piece. The members of the public will vote for the most interesting sculpture. In this way the students get engaged in the work that they have done, they take ownership of the work and feel responsible for it . They are able to talk about the things that they have learnt. In compliance with learning goals the students develop critical and socially engaged intelligence, which enables them to understand and participate effectively in the affairs of their community in a collaborative effort to achieve a common good. (John Dewey: Project on Progressive Ed)
Assessment - Evaluation	▪ A *self-assessment after stage 2 and stage 4*, ▪ A *group-assessment after stage 2 and stage 4* ▪ A project –evaluation *rubric at the end of the project (Edutopia rubric model)* ▪ Informal assessment: results of the competition during the display phase
Presentation - Reporting - Sharing	Short presentations by each group takes place during plenary sessions to show and discuss results of the work done. Individual presentations take place in the final event.
Extensions - Other Information	.

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

Open-air Museum

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
   These topics will be taught:
   - Town history through artistic and architectural features
   - Information search through media and data collection
   - Construction and use of virtual tour for public use
   - Building of creative artefacts
   - Presentation of tangible results

2. The world of the wider environment / work / business / parents / society / environment will be engaged

3. Target Age Group of Students - Associating with the Official Curriculum - Setting Goals and Objectives
   It can be taught in grade 8 , but the project is adaptable in higher or lower grades , with different levels of duration and learning goals.

4. Organization of the tasks of the parties involved - Designation of Coordinator - Workplaces etc.

   - T1 – Teacher of Art and Social Sciences
     Teaching connections between arts and society, landscape planning, community values
     Teaching interpretation and writing skills related to art topics

   Workplace: Classroom – Field work

   - T2 – Teacher of Technology and Computer Science

     Teaching the use of Google applications for the creation of the virtual tour
     Teaching the construction of an artifact
     Teaching presentation skills related to creative artefact construction

   Workplace: Computer Lab - Tech shop

STAGE II: Action Plan Formulation

1. Relation to the Real World – Reflection
   The project relates to the real world in that the students are growing to become responsible citizens who are expected to apply their competences to meeting the needs of the community. This will motivate both students and civil authorities to cooperate.

2. Formulation of a problem (possibly in stages or phases) resulting from the above
   The student / teacher team contact municipal authorities proposing support in the realisation of the project aiming at offering and selecting creative proposals to impact the quality of the urban landscape and the communal life.

3. Background Creation - Search / Gather Information
   Meetings are arranged – or preliminary contacts made - between teachers (and possibly representative students) and public authorities to inform about the project and check collaboration and feedback for final results.

   Prior knowledge and prerequisites are assessed (also informally).

4. Simplify the issue - Configure the problem with a limited number of requirements
   The teachers formulate the learning and action plan, setting the projects goals, connecting the outcomes to the curriculum, and identifying driving questions. The expected tangible results are defined.

5. Case Making - Designing - identifying materials for building / development / creation –workflow
   After the presentation of the project, the students, guided by the 1st teacher, work through phase 1 for the research and analysis of information and understanding of existing artistic realities in their town. They work in small groups of 3, each one dealing with different monuments/sculptures.

6. Observation-Experimentation
   Students gather information both through desk and field research about the city installations and collaborate to produce a written description of them. The descriptions are checked for content and form by the teacher and by the students themselves before being inserted in the virtual tour. The students in groups collaborate to the creation of the virtual tour on Google maps – my maps.

7. Studying the results – drawing initial conclusions - First presentation by students
   The students and teachers evaluate the quality of the virtual product created by comparing it to similar existing products and by testing its useability with other students/teachers and parents. If necessary, they will make some adjustments.

8. Repeat step 5 with additional requirements and under different conditions.

   After the conclusion of phase 1 and 2, the students, guided by the 2nd teacher, proceed through phase 3 to design and build a model of an artifact / or sculpture and prepare material to include descriptions and technical specifications of the model. The activity can be done in pairs or individually, depending on time available, students' individual skills, and whether the teachers' priority is that of inclusiveness. In this case, careful pairing of students will encourage discussion, collaboration and support for the less able.

9. Presentation of Conclusions - Communication Tactics.
   The presentation of conclusions will be done in a public event organised at the school with parents, members of the community and city authorities. The students will present their personal virtual tour on Google Maps, and they will display their installation proposals. They will take ownership of the work they have done and feel responsible for it being able to prove the knowledge and competences acquired in the process. The public members will give a vote to the art pieces, and the results of the competitions will assess the effectiveness of the product.

10. Applications in Everyday Life - Suggestions for Development (Entrepreneurship - SIL Days)
    Activity 9 involves public representatives, and the results of the competition may encourage the town officials to consider the ideas displayed for future landscape improvement plans.

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

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: 13-14	**Activities /Steps** Teacher 2 (T2) Cooperation with T1 and student guidance
A	Preparation of steps 1,2,3 (Stage1)– steps 2,3,4 (stage II)	Step 3 (stage II)	Cooperation in step 1,2,3 (Stage 1)- Steps 2,3,4 (stage II)
B	Guidance in step 5	5,6	Support guidance in step 5
			Guidance in step 6
C	Creative Evaluation 7	7	Creative Evaluation 7
D	Support Guidance 8	8	Guidance 8
G	Preparation of step 9	9	Preparation in step 9
K	Creative Evaluation 9	9	Creative Evaluation9
F	Organization (SIL) STEAME in life	10 Meeting with city representatives	Organization (SIL) STEAME in life

LEARNING & CREATIVITY PLAN (L&C PLAN):

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☒	☐	☒	☒	☒

1. Overview	
Title	A glass of hot chocolate!!!
Driving Question or Topic	*Which glass should I choose for hot chocolate?* *What is the most advantageous option?* *What should be the selling price of a glass of hot chocolate at the bazaar in order to make a satisfactory profit?*
Ages, Grades, …	*Age selection 13-15,* *Grades 7-9*
Duration, Timeline, Activities	*10 X 45 min* *Timeline/frame, calendar* *4*
Curriculum Alignment	Physics (heat), Mathematics (Geometry, Measurement, Statistics, Algebra)
Contributors, Partners	
Abstract - Synopsis	*The students organize a charity bazaar in which they will sell, among other things, a hot chocolate drink. They explore what kind of material they should choose for the glass in which they will serve the hot chocolate, in order to keep the temperature as long as possible and at the same time, this option is advantageous, in order to give them the most income. In the selected glass, a picture related to the theme of the action will be printed, which will be designed by the students. Students will have to come up with the most advantageous option, taking into account all the costs of purchasing the materials for making the chocolate, the glasses and printing the picture on them.* *The ultimate goal is to make a decision regarding the selling price of a glass of hot chocolate, which is within the market price range and at the same time brings them a satisfactory profit.*
References, Acknowledgements	
2. STEAME Framework*	
Teachers' Cooperation	• *Teacher 1 (T1-Mathematics)* • *Teacher 2 (T2-Physics)* • *Teacher 3 (T3-Art)* • *Teacher 4 (T4- Economics)* • *Teacher 5 (T5-Computer Science)*
STEAME in Life (SiL) Organization	
Action Plan Formulation	*Reference to the Stages and the Steps of the STEAME Framework (Action Plan Formulation)*
3. Objectives and Methodologies	
Learning Goals and Objectives	1. *To plan and perform a valid and fair experiment to investigate their hypotheses* 2. *To distinguish the variables that affect the temperature change of an object* 3. *Collect and record data using various methods, such as observation, measurement / recording* 4. *Construct frequency tables and graphs with the data they collect and interpret data tables and graphs*

	5. *Apply the reduction method to the unit to calculate the unit price of objects* 6. *To formulate arguments, which explain based on the data.* 7. *To make conjectures according to the conditions that prevail each time and carry out control procedures* 8. *Develop the ability to make effective decisions.*
Learning Outcomes and expected Results	1. *To draw and paint the outer surface in the appropriate glass and to construct it in a design program on the computer with an appropriate scale* 2. *Make a poster for the counter of their drinks* 3. *Make a price list of hot chocolate (or other drinks) for different sizes of glasses* 4. *To make an advertising spot (video) for the drinks they serve with reference to the advantages of the glasses they use and their advantageous prices*
Prior Knowledge and Prerequisites	1. *Graph construction (frequency polygons, bar graph) with ordered pairs* 2. *Proportions* 3. *Volume / capacity of solids (glass shape / truncated cone)* 4. *Surface area* 5. *Skills of using temperature measuring instruments*
Motivation, Methodology, Strategies, Scaffolds	*Inquiry based learning approach, collaborative learning, teamwork.*
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	*Procedures, spaces, and material preparation* *Setting in classroom, outdoor activity, computer lab etc*
Resources, Tools, Material, Attachments, Equipment	*Supermarket and coffee shop websites for collecting information on selling prices of beverages, raw materials and serving glasses of hot drinks, glasses of various materials (which can be found in supermarkets), thermometers, timer, square millimeter paper, painting materials, excel software, camera*
Safety and Health	*Attention in the Physics laboratory with the handling of hot water containers. Alternatively, students can use cold water and study again the temperature as a function of time.*
5. Implementation	
Instructional Activities, Procedures, Reflections	***Activity 1: Group-collaborative activity (groups of 4-5 students)(Worksheet 1)*** **• Brainstorm:** The thematic context is presented to the students and each student in the group is asked to write down in a worksheet all the elements that he/she thinks they should study, so that the sale of hot chocolate in the charity bazaar brings them a satisfactory profit. The students of each group discuss and come up with a list of elements-variables that they should study, which they present in plenary, justifying their choices. After discussion and argumentation, all students come up with a common list of items to deal with later. ***Activity 2: Group-collaborative activity (groups of 4-5 students) (Worksheet 2)*** ***• Selection of suitable glass material-conducting an experiment to determine which material keeps the water hot for a longer period of time.*** Students have at their disposal six glasses of different materials (aluminum, glass, porcelain, paper, plastic and polystyrene). All glasses have the same plastic cap, in which there is a suitable hole for inserting a thermometer in the glass. Each group of students will use two glasses of different materials to investigate which of them keeps the water hot longer. A specific amount of water at a temperature of 50 ºC will be placed in the glasses. Students make assumptions about which glass they think will keep the water warm for longer. They then measure the temperature of the water in each of the two glasses at regular intervals of one minute and record it on a double-entry board. Then they make the corresponding graph.

	The data collected by all the groups is recorded in an excel spreadsheet, where the students make a graph of the water temperature in the glasses as a function of time. Students interpret the multiple graph and draw conclusions about the temperature maintenance time in each different glass. ***Activity 3: Group-collaborative activity (groups of 4-5 students)*** ***• Milk and chocolate powder market research.*** Students search the supermarket websites for the prices of fresh milk and chocolate powder, in order to choose the most advantageous packages. They apply the method of reduction to the unit, in order to calculate the price of the unit in each package. They record the information they collect in tables (Worksheet 3) and come to conclusions regarding the most advantageous purchase of raw material for the manufacture of hot chocolate drink. ***• Survey for information on the selling prices of hot chocolate or other hot drinks from cafes that have a resident distribution of drinks.*** Students search the cafeteria websites that offer resident beverage distribution for hot chocolate selling prices to determine the price range and determine the selling price of their own hot chocolate. Record the information they collect in a table (Worksheet 3). (Information can also be collected on other beverages, such as tea). ***Activity 4:*** ***• Balance sheet.*** The students, after taking into account all the data they have studied and the conclusions they had reached in the previous activities, do market research on the packaging of the glasses they will buy (number of glasses in the package in relation to the price of the package) and costs printing the designs on them. Taking into account all the data related to costs and the suitability of the glass in terms of maintaining the temperature, they end up with the selling price of hot chocolate for two or three different sizes of glasses. ***Activity 5:*** ***• Painting.*** Each student is asked to measure the dimensions of the selected glass (the glass from the selected material can have different sizes) and to calculate the area of the side surface, in order to draw on the computer the side surface with the correct dimensions. The shape will be printed and then the students will create a drawing related to the theme of the action, where the most popular ones will be printed on the glasses for use in the charity bazaar. To select the drawings to be printed, students will photograph their drawings and submit them in google form, so that the students of the school can make their choice. ***Activity 6:*** ***• Advertising campaign-more sales*** Students make a poster for their beverage counter, a hot chocolate (or other beverage) price list for different glass sizes, and a promotional video for the beverages they serve with reference to the benefits of the glasses they use and their bargains.
Assessment - Evaluation	Formative assessment throughout students work. Peer evaluation of the final products of the teams.
Presentation - Reporting - Sharing	Presentation of the action to the students and teachers of the school. Presentation through the commercial, in the school bazaar.

STEAME 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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

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

LEARNING & CREATIVITY PLAN (L&C PLAN): Chair Design

S	T	En g	A	M	En t
☒	☒	☒	☐	☐	☐

1. Overview

Title	Chair Design		
Driving Question or Topic	Engineering Design process- Building chair prototype		
Ages, Grades, …	Ages: 12-15	Grade: 7-9	
Duration, Timeline, Activities	5h	Five to Seven 60minutes class periods	1 Activity
Curriculum Alignment	Science and Technology		
Contributors, Partners			
Abstract - Synopsis	Students become familiar with the engineering design process as they design, build, and test chair prototypes. The miniature chairs must be study and functional enough to hold a wooden, hinged artist model or a floppy stuffed animal. They use prototypes to assess design strengths and weaknesses.		
References, Acknowledgements	TeachEngineering https://www.teachengineering.org/activities/view/chair_design This engineering curriculum aligns to Next Generation Science Standards (NGSS).		

2. STEAME Framework

Teachers' Cooperation	1st Teacher: Physicist 2nd Teacher: Mechanical Engineer 3rd Teacher: Mathematics Teacher for teaching ratio and proportion concepts (the above three teachers can work together during all the activity period)
Action Plan Formulation	Engineers build prototypes for their creations before starting actual production. Prototypes enable engineers to assess design strengths and weaknesses through testing and so they can redesign to achieve successful end products. **Action Plan Overview:** **STAGE I:** Preparation steps for gathering prototype information. **STAGE II:** Lesson 1 and associated activity Plan formulation **STAGE III:** Lesson 2 and associated activity Plan formulation

3. Objectives and Methodologies

Learning Goals and Objectives	After this activity, students should be able to: 1. Describe and follow the steps of the engineering design process. 2. Assess prototypes for strengths and weaknesses.
Learning Outcomes and expected Results	Once the plan is completed, students will have designed, built and tested their chair prototypes.

Prior Knowledge and Prerequisites	Background: Before beginning the activity, lead a discussion with the class about engineering and what engineers do. Students should know that engineers follow the steps of the engineering design process as they work. The basic steps are asking to identify the problem, research, imagine possible solutions, plan, create a prototype, test, and improve. Engineers are responsible for designing everything in the human-made world. What might this include? (Have students name a few items.) Yes, they design airplanes, bridges, cars, computers, computer keyboards, etc. It's obvious that you would need someone to design these things. Engineers are also responsible for designing the less obvious products. How about boxes? Teams of engineers are responsible for designing cardboard boxes to serve very specific purposes. What types of things do you think they consider as they design boxes? • What will the box be holding? • Will the box be shipped? • Is the cargo delicate? • Can it spoil? • How high will the boxes be stored? How much weight must each box need to hold? • What could happen if the boxes are not tested before being used? What could happen if the box is not sturdy enough for the cargo? • The cargo could become ruined. • The company shipping the cargo could lose money. • If liquid, the cargo could leak and pollute the surrounding environment. • If the cargo is ruined or unable to make the trip, trouble could arise for the person who ordered it. You can see that a lot of thought must go into each item that is designed. The design of the box changes depending on what is inside. You could have two items that require the same size box, but the box would need to be different because one box is for a bottle of liquid medicine and the other box is for pens. How do you think this would affect the box design? Think about a chair. It might be hard to imagine that engineers are still designing chairs considering how long they've been around but think of a baby's highchair vs. a chair in a doctor's office. What factors must engineers consider as they design chairs? • Where will the chair be located? (kitchen/doctor's office) • How often will the chair be used? (3 x day/all day) • Will people be doing anything else as they sit in the chair? (eating/reading) • Will this chair get dirty often? (yes/hopefully not) • Who will use the chair? What are the physical characteristics of the user(s)? (under 30 pounds/possibly hundreds of pounds) The answers to these questions help to dictate the design. For example, a chair in a doctor's office can be covered in fabric. But, this would be a bad idea for a baby's highchair since it gets so dirty every day. For the next few weeks, you will act as engineers. You will work in teams to design and build a chair prototype with the constraint of using only gauge wire within the allotted time. You will outline where your chair will be located, who will sit in it, etc. Then, you will design and build a prototype. As you work, you will follow the steps of the engineering design process and record your design process in an Engineer's Journal. You will use wire for your chair prototype but think about what kind of materials you would use when you turned your prototype into a real chair.
4. Preparation and means	
Preparation, Space Setting, *Troubleshooting Tips*	There will be 5-7 60-minute sessions, depending on how fast students work; These sessions can take up to 2 days for designing and building and approximately 3 days for testing and re-designing. Preparation steps: 1. Have examples of chairs of different designs. 2. Gather materials and make copies of the My Chair Design Journal

Resources, Tools, Material, Attachments, Equipment	**Materials List:** **Each group needs:** 1. 10 meters of 18-gauge wire for each prototype (jewelry wire seems to be the least expensive, available at craft and bead stores or online) 2. My Chair Design Journal, one per student 3. To share with the entire class: 4. measuring tape 5. soldering iron (or wire finer than 18-gauge to secure main chair wire structure) wooden artist model or floppy stuffed animal Worksheets and Attachments Chair Design Matrix (pdf) My Chair Design Journal (pdf) Visit [www.teachengineering.org/activities/view/chair_design
5. Implementation	
Instructional Activities, Procedures, Reflections	1. Guide students through the brainstorming process to learn about brainstorming and start thinking about what really makes a chair. Have students write additional brainstorming ideas in an engineering journal. The final chair must be sturdy enough to be dropped from ankle-height, support a stuffed animal or a hinged, wooden artists model, and appear to be comfortable. 2. Discuss the engineering design process with students. Explain that they will be designing a chair and building prototypes of the chair, following the steps of the engineering design process as they work. 3. Explain to students that engineers work in teams and that one of the team members practices "human factors" to help them as they design. Human factors experts help engineers to design products and devices that will work for many people. In this case, they help engineers design chairs that are functional for people of differing heights and weights. 4. Have students measure their heights and compare to the class mean. 5. Students should next design an uncomfortable chair. Draw the chair design in their engineering journals before they build. 6. Once they have designed an uncomfortable chair, have them build the chair with the wire. Use either a finer gauge wire to bind the wire or solder the wire. 7. After students have built their chairs, bring together the class so each student can present his/her design to the group. This exercise helps to facilitate a discussion about features that make the chairs uncomfortable, which, in turn, helps students focus on what makes chairs comfortable. 8. Next, have students redesign the chairs based on the knowledge they gained from their first prototypes. Test the chairs by placing the wooden model or floppy stuffed animal on them; a chair should be able to support the model/stuffed animal. 9. Conclude the activity by giving each student time to present his/her redesigned chairs to the class. Require that they describe their chair's strengths and what they would change in the next iteration (next version, for improvement) of the design
Assessment - Evaluation	**Assessment** Activity Embedded Assessment Design Journal: As students progress through the activity, have them fill in the prompted questions and sketches in the attached My Chair Design Journal. Review their answers to gauge their comprehension of the subject. Post-Activity Assessment

Presentation - Reporting - Sharing	Evaluation Rubric: Evaluate students using the attached Chair Design Matrix, which includes the criteria categories of brainstorming, imaging-planning-improving, creating, sharing and prototype design. Students present their prototypes to the class.

STEAME 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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

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

LEARNING & CREATIVITY PLAN (L&C PLAN): THE CHANGE OF A RIVER

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☒	☐	☒	☐	☐

1. Overview			
Title	THE CHANGE OF A RIVER		
Driving Question or Topic	How has the Missouri River changed over the past 200 years? What transformations have taken place in this area's atmosphere, biosphere, hydrosphere and lithosphere?		
Ages, Grades, …	AGES: 14 - 18	9th – 12th grade	
Duration, Timeline, Activities	5 LEARNING HOURS	Five 45-60 minute class periods	5 SESSIONS OF ACTIVITIES
Curriculum Alignment	Social Studies Language Arts Technology		
Contributors, Partners			
Abstract - Synopsis	Students will describe the changes that have affected the Missouri River over the past 200 years by identifying transformations in this area's atmosphere, biosphere, hydrosphere, and lithosphere.		
References, Acknowledgements	https://www.usmint.gov/learn/educators/lessons-by-grade		
2. STEAME Framework			
Teachers' Cooperation	1st Teacher: Social Studies Classroom This teacher will guide students in the research of journals about the state of the river in the early 1800s, about The Corps of Discovery, the story of the Louisiana Purchase and Lewis and Clark's exploration of the American West He has to help students discuss what effects the changes they noted would have on their research area as well as on society. 2nd Teacher: Arts Classroom The Art teacher will guide students to design a new nickel reverse that commemorates the role of the Missouri River over the past 200 years. This drawing and an explanation of their design should be added to each student's journal. 3rd Teacher: Technology Computer lab The ICT teacher has to help students prepare their presentations using multimedia tools in the computer lab. (The three teachers can work together during the whole project)		
STEAME in Life (SiL) Organization	Provide students with the opportunity to contact local, state, or federal policymakers regarding environmental issues.		
Action Plan Formulation	**STAGE I:** Preparation by one or more teachers [STEPS 1-3], and **STAGE II**: Action Plan Formulation [Preparation STEPS 1-3]… Refers to the creation of this Learning Plan, by teachers in collaboration.		

	STAGE II: Action Plan Formulation [Development STEPS 4-15]… Refers to the realization by the students of the activities of the Learning Plan. **STAGE II:** Action Plan Formulation [STEPS 16, 18]… Refers to the realization by the students of the activities of the Learning Plan. The support, feedback and evaluation by the teachers is accompanying throughout the implementation of the activities and not only the final result.
3. Objectives and Methodologies	
Learning Goals and Objectives	By the end of the L&C Plan, students will know what changes have affected the Missouri River over the past 200 years by identifying transformations in this area's atmosphere, biosphere, hydrosphere, and lithosphere.
Learning Outcomes and expected Results	The expected results are: • allow students to work in pairs to conduct their initial sphere research. • assign research team roles according to learning styles. For example, someone who excels at writing could be the research team recorder; someone who is artistic could design the group coin.
Prior Knowledge and Prerequisites	Students should have a basic knowledge of: •The Corps of Discovery •Waterways •Computer presentation program functionality They should also know the meaning of following Terms and Concepts: •Obverse (heads) •Reverse (tails) •Reservoir •Lewis and Clark •Corps of Discovery •Sandbar •Keelboat •Peace medal •Ecosystem •Atmosphere •Biosphere •Hydrosphere •Lithosphere •Pro •Con
Motivation, Methodology, Strategies, Scaffolds	The main methodology of this project is based on enquiry-based learning, an active learning that starts posing questions, problems and scenarios. Students will identify and research issues to develop knowledge and solutions. Inquiry-based learning prioritizes problems that require critical and creative thinking so students can develop abilities to ask questions, design investigations, interpret evidence, form explanations and arguments and communicate findings. Students are invited to reflect on natural changes and to identify transformations in the atmosphere. From these observations they can learn how to impact on today environment.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	Preparations: •Make an overhead transparency of each of the following: ▪Peace Medal Nickel reverse from the Resource Guide. ▪Keelboat Nickel reverse from the Resource Guide. •Locate copies of journal entries in which Lewis and Clark describe the river's state in the early 1800s (see examples under "Materials"). •Make copies of each of the following: ▪"Changes in Our Environment" assignment sheet (1 per student). ▪"Individual Research Journal Rubric" (1 per student). ▪"Presentation Rubric" (1 per student).

	▪"Atmosphere Team Guide" (1 per atmosphere team). ▪"Biosphere Team Guide" (1 per biosphere team). ▪"Hydrosphere Team Guide" (1 per hydrosphere team). ▪"Lithosphere Team Guide" (1 per lithosphere team). •Make one copy of "Research Teams" and cut it along the dotted lines. •Arrange to use the school computer lab for four class sessions. •Arrange to use the school library for three class sessions (optional). •Bookmark appropriate Internet sites. GROUPINGS • Whole group • Pairs • Small groups • Independent work Worksheets and rubrics are available at following website: https://www.usmint.gov/learn/educators/lesson-plans/the-change-of-a-river
Resources, Tools, Material, Attachments, Equipment	Materials •1 overhead projector •1 overhead transparency of each of the following: ▪Peace Medal Nickel reverse from the Resource Guide ▪Keelboat Nickel reverse from the Resource Guide •Copies of each of the following: ▪Multiple journal entries in which Lewis and Clark describe the river's state in the early 1800s, such as those written on June 14, 1804, and May 11, 1805 ▪"Changes in Our Environment" assignment sheet ▪" Individual Research Journal Rubric" ▪"Presentation Rubric" ▪"Research Teams" sheet ▪"Atmosphere Team Guide" ▪"Biosphere Team Guide" ▪"Hydrosphere Team Guide" ▪"Lithosphere Team Guide" •Small notebooks or journals (1 per student) •1 copy of the "Research Teams" sheet •A reserved computer lab with Internet access and a computer presentation program •A reserved section of the school library (optional) •Web sites that include basic information on the Corps of Discovery's impression of the Missouri River structure and ecosystem, such as: ▪www.pbs.org/lewisandclark/archive/idx_jou.html ▪www.conservation.state.mo.us/conmag/2004/01/20.htm ▪www.lewisandclarkeducationcenter.com/ •Web sites that include basic information on the current Missouri River structure and ecosystem, such as: ▪nd.water.usgs.gov/lewisandclark/dams.html ▪www.nwd.usace.army.mil/pa/missouri2003aop.asp ▪www.epa.gov/msbasin/missouri.htm ▪www.conservation.state.mo.us/conmag/2004/01/20.htm ▪news-info.wustl.edu/tips/page/normal/840.html ▪www.northern.edu/natsource/HABITATS/Missio1.htm ▪www.wildmontana.org/missouririverbreaks.html ▪mdc.mo.gov/kids/out-in/2003/01/2.htm ▪wrc.iewatershed.com/watershed-national-10.php

	•Poster board or butcher paper (1 sheet per group) •Markers and/or colored pencils •1 computer projector •1 projection screen
Safety and Health	
5. Implementation	
Instructional Activities, Procedures, Reflections	This L&C plan can be implemented in 5 learning hours. All the teachers are called to cooperate in every session of the implementation, but each of them will have a predominant task according to their competence and field of expertise.
Social studies teacher Art teacher	**Session 1** 1.Display the overhead transparencies of the Peace Medal Nickel reverse and the Keelboat Nickel reverse. Direct the students to inspect the images on the transparencies. Ask the students what they know about these two images and what they represent. 2.Explain that, starting in 2004 and continuing through 2005, our nation is changing its nickels to tell the story of the Louisiana Purchase and Lewis and Clark's exploration of the American West 200 years ago. Inform students that these are the reverse designs that appear on the 2004 nickels. 3.Ask students to recall some basic historical information about the Louisiana Purchase and the Corps of Discovery's expedition. They should remember that Captains Meriwether Lewis and William Clark led the Corps of Discovery up the Missouri River in an effort to find a Northwest Passage to the Pacific Ocean, which would eventually assist with the nation's abilities to conduct trade. Along their journey, they developed relations with many groups of American Indians and conducted scientific studies of the animals, plants, land, and water in this region. 4.Make connections between these missions and the new nickels by noting that the Corps of Discovery members rowed, poled, and pulled a keelboat like the one pictured on the Keelboat Nickel. Also explain that the explorers gave peace medals that had an image on them like the image on the Peace Medal Nickel reverse to the American Indians as a sign of good will. 5.Conduct a Think-Pair-Share activity in which the students, first individually and then with a partner, brainstorm ideas about the important role that the Missouri River played in the journey of the Corps of Discovery. Once the students have discussed their ideas with their partners, conduct a class discussion in which these ideas are shared. 6.Explain to the students that the Corps, including the captains, kept journals of their experiences during the trip. The journals were full of descriptions of the wild, winding, turbulent, unrestricted Missouri River. Provide students with a sample of one or two journal entries that describe the river's state in the early 1800s. 7.Explain that they are going to conduct their own exploration of the Missouri River and its role in modern society as a class. Distribute a "Changes in Our Environment" assignment sheet to each student. Direct a student to read it aloud to the class. 8.Distribute one small notebook or journal to each student. Inform them that, during this investigation, each student must maintain a journal, which will be assessed at the end of the lesson. 9.Distribute a copy of the " Individual Research Journal Rubric" to each student. Review the rubric with the students and inform them that these are charts of what they have to accomplish in their individual research journals for various degrees of achievement (in other words, this is how they'll be graded). 10.Direct the students to take a moment at this time and write a journal entry in which they describe what they currently know about the state of the Missouri River in 1803. They should also hypothesize about what changes they believe may have occurred on the river since that time, and the possible causes for the changes. 11.Re-read the "Changes in Our Environment" assignment sheet and introduce the students to the core of their "jigsaw" research project. Explain that the students will

ICT teacher	be divided into groups that will explore the impact of changes that have been made to the Missouri River. 12.Direct the students to assemble themselves into four groups. Place the cut-outs from the "Research Teams" page into a hat and have a member of each group draw one team research assignment. This will inform the group of their duties for the first part of this project. Distribute the appropriate "Team Guide" to each group based on the team description they selected from the hat. 13.Ask the students to share their earlier journal entries with their research team, noting in their journals their peers' ideas as they are discussed. They should discuss what effects the changes they noted would have on their research area as well as on society. 14.Tell the students to discuss within their research teams what they need to know about the river and their sphere of expertise for this project. These questions and issues will guide their research. They should list these in their journals. 15.Direct the students to develop a plan for finding what they need to know. This plan should include an outline of individual investigative responsibilities. Each student must write their individual research plan (i.e. questions to answer and resources to use) in their journal. 16.Direct the students to complete their individual research plans for homework if they did not finish them during this class session.
Social studies teacher Technology teacher Art teacher	**Session 2** 1.Explain that the students must now implement the independent research plans they described in their journals. They should record their findings, sources, and any new questions in their journals. Explain that they may use the Internet or library resources to investigate the Missouri River's structure and ecosystem two hundred years ago through the eyes of the Corps of Discovery. They should investigate the river's structure and ecosystem today by reviewing current research and information on the Internet. If appropriate, guide your students to the Web sites suggested in the Materials section of this lesson plan. 2.Accompany your students to either a school computer lab or the school library and allow them about fifteen minutes to begin their investigation. Observe what the students are researching. If necessary, step in with guiding questions such as the ones on the sphere team guides to keep students on the right investigatory path. 3.When the majority of the students are finished with their initial investigation plan, ask them to reassemble in their research teams to discuss their findings. In their teams, the students should develop new questions based on the information the team gathered, and they should note these questions in their journals. 4.Direct the students to adjust their individual research plans based on their group discussion. Any adjustments or new questions should be recorded in their research journal. 5.Allow the students to research any new questions that have arisen. 6.Repeat steps 4 through 6 as many times as necessary until students have at least touched on the learning issues listed in the sphere team guides. 7.Now that students are "experts" on their area of research, direct them to assemble into new teams that contain representatives from each of the spheres. In these groups, the students should discuss their findings and begin to formulate their group's presentation. 8.Based on the group's discussion, direct the students to independently write a journal entry in which they hypothesize about the future of the Missouri River. They should focus primarily on their sphere of expertise, but should also touch upon each of the other spheres. 9.Once more, display the overhead transparencies of the Peace Medal Nickel reverse and the Keelboat Nickel reverse. Based on their research, for homework, require each student to design a new nickel reverse that commemorates the role of the Missouri River over the past 200 years. This drawing and an explanation of their design should be added to each student's journal. **Sessions 3 and 4** 1.Allow the students to complete any individual research that may remain from the previous sessions.

Technology teacher	2.Direct the students to reassemble into their groups from the previous session. 3.Distribute a copy of the "Presentation Rubric" to each student. Review the rubric with the students and explain that the presentations should include information on the river's past and present structure and ecosystem with emphasis on how changes in the structure over the past 200 years have affected the land, air, water, and living things in the Missouri River ecosystem. Through the inclusion of scientific facts, the presentations should explain the positive and negative effects of these changes on society. Explain that, in groups, each individual will take on a research role. Explain, too, that all of the research will be combined to form the group presentation.
Art teacher	4.Direct the students to design and create their group presentations, which are to be 15 minutes in length. The students should develop a plan for the actual creation of this presentation, so that all students can participate. The students should also share and discuss their last journal entries and individual thoughts on the future of the Missouri River, as this will be incorporated into the group presentation. 5.Distribute a piece of poster board or butcher paper to each group. Direct the students to share their individual nickel designs and combine ideas in order to develop a group nickel design. This design should be included in their presentation. 6.Explain that the groups will share their presentations during the next session, so any incomplete work must be completed as homework. 7.Ten minutes before the end of the session, have the students take a moment to write a journal entry describing how they feel about the changes that have taken place on the Missouri River over the past 200 years, based on the research they've conducted and their group discussions.
Technology teacher	**Session 5** 1.Direct each group to give their 15-minute presentations. 2.After each presentation, allow five minutes for your questions as well as those from other students. 3.Ten minutes before the end of the session, direct the students to write a journal entry describing how they feel about the changes that have taken place on the Missouri River over the past 200 years now that they've heard from the other groups. Has their view changed since their last journal entry? Why or why not? 4.Collect the individual research journals. Worksheets and rubrics are available at following website: https://www.usmint.gov/learn/educators/lesson-plans/the-change-of-a-river
Assessment - Evaluation	The assessment will be the result of following actions: • Take anecdotal notes about the students' ability to work as a team, to complete independent research, and to meet all the other project objectives. • During the presentations, note the students' performance in each of the categories outlined in the "Presentation Rubric." Assess their work accordingly. • Read the individual research journals and assess them using the "Individual Research Journal Rubric." A continuous monitoring and evaluation is done throughout the learning plan with a special focus on the students' ability to cooperate, share proposals, solve problems and debating.
Presentation - Reporting - Sharing	As described in detail in the above sessions, there are different moments during the L&C plan where students are asked to share ideas, make presentations and to report about their work.
• *Extensions - Other Information*	• Direct the students to investigate and present research relating to local environmental changes. •Provide students with the opportunity to contact local, state, or federal policymakers regarding environmental issues.

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

THE CHANGE OF A RIVER

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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

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 3 (T3) Cooperation with T1 and T2 and student guidance
A	Preparation of steps 1,2	1,2	
B	Teaching - Guidance in step 3,4	3,4	
C	Teaching – Guidance 5	5	Teaching – Guidance 5
D	Guidance – Evaluation 6,7	6,7	Support 6,7
E	Guidance	8,9,10,11,12,13	Teaching – Guidance - Support
F	Organization (SIL) STEAME in Life	14 Meeting with local, state, federal policymakers	Organization (SIL) STEAME in Life
G	Preparation of step 15	A	Cooperation in step 15
H	Guidance	16 (repetition 5-11)	Support Guidance
I	Guidance	17	Support Guidance
K	Creative Evaluation	18	Creative Evaluation

LEARNING & CREATIVITY PLAN (L&C PLAN): WHO MOVED THE BEACH?

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☒	☒	☐	☐	☒

1. Overview

Title	WHO MOVED THE BEACH?
Driving Question or Topic	What are the primary causes and impacts of coastal erosion, and how should human communities respond to this process? PRESENTATION OF THE L & C Plan: Coastal erosion is a natural process that sweeps large sections of land out to sea. Students will learn about how this process occurs and then explain how human activity can increase erosion risk. They will then determine how to reduce these risks, understanding both the advantages and disadvantages of various options. Students will also look a beach elevation data and make predictions on how vulnerable they are to erosion.
Ages, Grades, … Duration, Timeline, Activities	AGES: 14 - 18 — 9th – 12th grade 4 LEARNING HOURS — Four 45-minute class periods, plus time for student research — 4 ACTIVITIES
Curriculum Alignment	Science as Inquiry, Physical Science, Earth and Space Science, Science and technology, Science in Personal and Social perspectives, Geography
Contributors, Partners	
Abstract - Synopsis	High school students working in groups of three to four learn about the primary causes and impacts of coastal erosion, and use elevation data to construct profiles of three beaches, make inferences about the erosion process, and discuss how humans should respond.
References, Acknowledgements	www.asee.org Created by the American Society for Engineering Education (ASEE), this blog aims to be both a networking site for teachers and a trustworthy source of information and opportunities. The activity has been adapted from the National Oceanic and Atmospheric Administration's coastal management lesson plans.

2. STEAME Framework

Teachers' Cooperation	1st Teacher: Science Teaching the causes of the coastal erosion: storms, floods, shoreline erosion, other natural hazards and land subsidence. Classroom 2nd Teacher: Geography Teaching how to identify areas most likely to be affected by erosion. Classroom

	3rd Teacher: Engineering Teaching what engineering solutions protect coastlines, which engineering solutions suit a particular type of coastline. Classroom 4th Teacher: Entrepreneurship This teacher is responsible of students' possible internships in companies working on the problem of coastal erosion. His task is to boost students' interest in this topic and make them consider it as a possible future job. (The four teachers can work together after the first session of the project)
STEAME in Life (SiL) Organization	A meeting with experts such as: - scientists who know how to classify waves according to their sizes And - engineers who work on the possible solutions to reduce damages and on the methods of coastal protection (natural systems and artificial ones).
Action Plan Formulation	**STAGE I:** Preparation by one or more teachers [STEPS 1-3], and **STAGE II**: Action Plan Formulation [Preparation STEPS 1-3]… Refers to the creation of this Learning Plan, by teachers in collaboration. **STAGE II:** Action Plan Formulation [Development STEPS 4-15]… Refers to the realization by the students of the activities of the Learning Plan. **STAGE II:** Action Plan Formulation [STEPS 16, 18]… Refers to the realization by the students of the activities of the Learning Plan. The support, feedback and evaluation by the teachers is accompanying throughout the implementation of the activities and not only the final result.
3. Objectives and Methodologies	
Learning Goals and Objectives	By the end of the L&C Plan, students will be able to: - *identify* coastal erosion as a natural process and - *explain* how human activity can increase the risks associated with coastal erosion.
Learning Outcomes and expected Results	After the project, students will be able to identify options for reducing risks caused by coastal erosion, and discuss the advantages and problems associated with these options. They will be able to analyze and interpret beach elevation data, and make inferences from these data about the relative vulnerability of different beaches to coastal erosion.
Prior Knowledge and Prerequisites	Basic knowledge of the meaning of the key words: - Erosion - Accretion - Longshore transport - Dune - Berm - Beach profile
Motivation, Methodology, Strategies, Scaffolds	The main methodology of this project is based on enquiry-based learning, an active learning that starts posing questions, problems and scenarios. Students will identify and research issues to develop knowledge and solutions. Inquiry-based learning prioritizes problems that require critical and creative thinking so students can develop abilities to ask questions, design investigations, interpret evidence, form explanations and arguments and communicate findings. Students are invited to reflect on a real problem that affects our earth and, analyzing and comparing data from different beaches, they can make inferences from these data and come to some conclusions and suggestions about how to reduce the damages due to coastal erosion.

4. Preparation and Means

Preparation, Space Setting, *Troubleshooting Tips*	Seating Arrangement: Classroom style or groups of 3-4 students Maximum Number of Students: 30 Materials: •Computers with Internet access •Copies of "Coastal Erosion Subject Review Worksheet; one copy for each student or student group •Graph paper or computers with spreadsheet and graphing software Background Information: Almost half of the people living in the United States live near the coast. As the coastal population continues to grow, more people and property will be exposed to hazards caused by severe storms, floods, shoreline erosion and other natural hazards. Homes and businesses are often built in low-lying areas and barrier islands that are particularly vulnerable to storm damage. The potentially disastrous consequences of this trend became obvious during the summer of 2004 when residents of Florida were battered by four major hurricanes within six weeks, resulting in billions of dollars worth of damage. Much of the price is eventually borne by American taxpayers through federal government funds for disaster relief and reconstruction. While erosion and land subsidence (land sinking below sea level), are less spectacular than strong storms, they are just as important in economic terms. Erosion alone is estimated to cause billions of dollars of damage every year along U.S. coasts. Subsidence around New Orleans has necessitated large expenditures for pumping and dike maintenance. Subsidence in Texas, Florida, and California threatens high-value land uses and causes damages that cost millions to repair. Attempts to protect against coastal hazards can cause additional problems. Sea walls intended to protect against storm waves can actually accelerate beach erosion and reduce the capacity of beaches to absorb storm energy. As a result, buildings adjacent to the beaches are exposed to the full force of wind and waves. Human activities such as diking and drainage of land around New Orleans, ground water removal in Texas and Florida, and extraction of oil and gas in California have accelerated subsidence in these areas (see, for example, http://ga.water.usgs.gov/edu/earthgwlandsubside.html). Experience has shown that prevention is the best approach to deal with these problems. It costs much less to prevent construction in areas unsuitable for development than to provide funds for emergency response, cleanup, and reconstruction. NOAA's Office of Ocean and Coastal Resource Management works in partnership with state governments to minimize the impact of coastal hazards by • Identifying areas that are most likely to be severely affected by these hazards; • Developing warning systems and response plans to minimize human exposure to hazardous events; • Establishing appropriate building codes; and • Restoring the natural protective functions of beaches and dunes. From 1996 to 2000, the National Ocean Service, NASA, and U.S. Geological Survey partnered in an Airborne LIDAR Assessment of Coastal Erosion (known as the ALACE project). LIDAR stands for light detecting and ranging, and is part of NASA's Airborne Topographic Mapper (ATM). The ATM system uses a laser altimeter installed in an aircraft. As the aircraft flies along the coast, the altimeter scans the earth's surface in a path several hundred meters wide, and acquires an estimate of ground elevation every few square meters. The ALACE project collected topographic data (elevations of dunes and beaches) along U.S. coasts. These data have been used to create maps that show the relative vulnerability to coastal erosion. These maps can be used to quickly locate areas that may be severely impacted by coastal storms, to help plans for emergency response as well as

	environmentally appropriate development. For more information on LIDAR mapping, visit http://www.csc.noaa.gov/products/nchaz/htm/ldarmenu.htm.
Resources, Tools, Material, Attachments, Equipment	Resources: https://coast.noaa.gov/ – National Coastal LIDAR data from NOAA's Coastal Services Center – Beach Nourishment: A Guide for Local Government Officials from the NOAA Coastal Services Center https://www.heinzctr.org/ – summary (23 pages, 544 kb) and full (252 pages, 3.9 mb) report, "Evaluation of Erosion Hazards" prepared by the H. John Heinz III Center for Science, Economics and the Environment http://coastal.er.usgs.gov/hurricanes/ – U.S. Geological Survey "Hurricane and Extreme Storm Impact Studies" webpage http://archives.cnn.com/2000/fyi/news/09/20/coastal.erosion/index.html – CNNfyi article, "Beaches on the brink" Reports and articles needed to complete worksheet: "Evaluation of Erosion Hazards," (Summary) April 2000 report prepared for the Federal Emergency Management Agency by the H. John Heinz III Center for Science, Economics, and the Environment. Read full report. NOAA's Coastal Hazards Assessment. National Assessment of Storm-induced Coastal Change Hazards. Beaches on the Brink. 2000 CNN report. For Educators: Labs, Lessons & Other Hands-on Coastal Geography and Environmental Engineering Science sites: The BRIDGE," an ocean of free, teacher approved marine science education resources" from the College of William and Mary's Virginia Institute of Marine Science, includes a "immerging properties" seal level investigation using data, "where's the beach" Data activity that uses data to analyze erosion and a coastal geology lab from Oregon State University. Live near a beach? Take your own beach profile measurements. (See the University of Maine's helpful how-to guide for volunteer beach monitors.) Or use the University of Hawaii's sea-level data to compare how beaches are shifting in different U.S. coastal regions. Graphing the Beach Profile. How-to guide from the education program of the New Jersey Sea Grant Consortium includes how to count bird and human tracks.
Safety and Health	
5. Implementation	
Instructional Activities, Procedures, Reflections	This L&C plan can be implemented in 4 learning hours. The first lesson can be introduced by showing images of severe coastal erosion, such as that caused by hurricanes. You can visit the NOAA photo library at http://www.photolib.noaa.gov/ 1. ACTIVITY N. 1 (45 minutes): Completion of the worksheet Tell students that their assignment is to learn about coastal erosion processes by completing the "Coastal Erosion Subject Review Worksheet." http://teachers.egfi-k12.org/wp-content/uploads/2017/05/COASTAL-MANAGEMENT-REVIEW-SHEET.docx

	If students do not have access to the Internet, download copies of materials cited at the beginning of the worksheet and make one copy of each article available to each student or student group. 2. ACTIVITY n. 2 (45 minutes): Review answers for the worksheet 3. ACTIVITY N. 3 (45 minutes): Review the idea of the ALACE project and LIDAR mapping (which students may have encountered while researching answers for the worksheet). Ask students what sorts of beach profiles might be most resistant to wave erosion. Provide each student or student group with copies of the text file "threebeaches.txt" and instruct each group to plot each of the four sets of data on a single graph. If possible, have students import the data into a spreadsheet program (such as Microsoft Excel) and use this program to construct their graph. 4. ACTIVITY N. 4 (45 minutes): Lead a discussion of students' beach profiles. Ask students to infer which of the three beaches might be most vulnerable to wave erosion. Paradise Beach and Shell Beach both have conspicuous dunes, while Donkey Beach has a lower elevation and would be more susceptible to erosion by waves. Ask what might account for the differences in the two profiles for Paradise Beach. Students should recognize that in March the beach may have been recently exposed to winter storms that increase erosion and move sand offshore, but that by September this sand could have been returned by the gentler waves typical of summer months. Be sure students realize that the offshore areas that receive eroded sand are obviously involved in these processes, and in fact are part of the total beach profile. Discuss the three options for responding to erosion threats listed in the last question on the worksheet. Students should realize that while leaving may be the least expensive option, this is often impractical where development has already taken place. Renourishment, however, is seldom a permanent solution. Similarly, various construction options can make property more resistant to erosion, but structures such as sea walls, jetties, and bulkheads often increase erosion and shift the problem to other areas by interrupting the natural flow of sand. The Me Connection Many people who live in erosion-prone areas believe that they have the right to take whatever steps are necessary to protect their property from erosion. For example, a 1998 report in the Maryland Law Review points out that more and more houses are being built just inland of sandy beaches that are generally considered to be public lands. Because sea level is rising and most shores are eroding, the ocean will eventually reach these houses unless the houses are moved or the sea is held back. The most common "solution" is to build a wall between the private dry land and the public beach. The result is that the private land is saved and the beach erodes away. In Maryland alone, more than three hundred miles of tidal shoreline have been "armored" in the last 20 years.
Assessment - Evaluation	The assessment and formative evaluation is the completion of the worksheet and the number of correct answers given. Moreover, a continuous monitoring and evaluation is done throughout the learning plan with a special focus on the students' ability to cooperate, share proposals, solve problems and debating.
Presentation - Reporting - Sharing	Students have to write an essay explaining why they support or reject the suggested approach, and what arguments might be offered by someone with a view that opposes their own.

Extensions - Other Information	Visit: http://www.mostreamteam.org/ for information on building and using a stream table to simulate erosion and other processes involving sediment transport by water (presented by the Missouri Stream Team Info center). Activity Extensions: Build and use a stream table to simulate erosion and other processes involving sediment transport by water. (Source: Missouri Stream Team Information)

STEAME 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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

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 3 (T3) Cooperation with T1 and T2 and student guidance
A	Preparation of steps 1,2	1,2	
B	Teaching - Guidance in step 3,4	3,4	
C	Teaching – Guidance 5	5	Teaching – Guidance 5
D	Guidance – Evaluation 6,7	6,7	Support 6,7
E	Guidance	8,9,10,11,12,13	Teaching – Guidance - Support
F	Organization (SIL) STEAME in Life	14 Meeting with scientists and engineers	Organization (SIL) STEAME in Life
G	Preparation of step 15	A	Cooperation in step 15
H	Guidance	16 (repetition 5-11)	Support Guidance
I	Guidance	17	Support Guidance
K	Creative Evaluation	18	Creative Evaluation

LEARNING & CREATIVITY PLAN (L&C PLAN): THE CREATION OF MY OWN E-SHOP

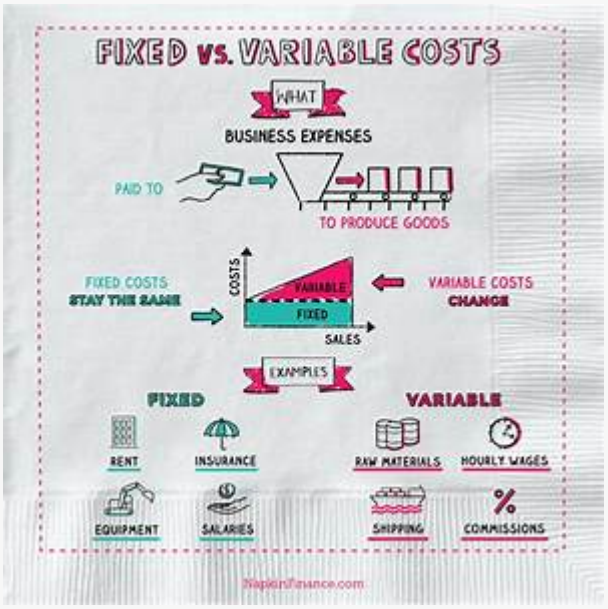
S	*T*	*Eng*	*A*	*M*	*Ent*
☐	☒	☐	☒	☒	☒

1. Overview	
Title	THE CREATION OF MY OWN E-SHOP
Driving Question or Topic	WHAT I NEED TO KNOW ABOUT THE COSTS, REVENUE AND PROFIT IN MY BUSINESS?
Ages, Grades, …	AGES:15-16 9th - 10th grade
Duration, Timeline, Activities	4 LEARNING HOURS 2*90 MINUTES 6 ACTIVITIES
Curriculum Alignment	BUSINESS COSTS, REVENUE AND PROFIT
Contributors, Partners	
Abstract - Synopsis	Five activities for two learning periods of 90 min (first lesson) include the analysis and the calculation of a firm's profit, the analysis of its costs and how this firm creates and increases its revenue. So, for all these reasons, in the second period of 90 min (second lesson), every group of students designs and creates a customized e-shop, that formulates a real problem. In this way, they understand the mechanism of the market in action.
References, Acknowledgements	• Pearson Edexcel International GCSE (9-1) Economics -First published 2017, author: Rob Jones. ISBN 978-0-435-18864-1 (Student's book). Case Study (Lesson 16): Greenway Construction (activity 1). • Pearson Edexcel International GCSE (9-1) Economics -First published 2018, author: Clare McCormack. ISBN:978-0-435-19134-4 (Teacher Resource Pack).
2. STEAME Framework	
Teachers' Cooperation	1st Teacher: Economist 2nd Teacher: Technology Specialist and/or Computer Scientist (the two teachers can work together during the second lesson)
STEAME in Life (SiL) Organization	A real meeting with a businessman whose main activity is organizing and running an e-shop.
Action Plan Formulation	**STAGE I**: Preparation by two teachers [STEPS 1-4], and **STAGE II**: Action Plan Formulation [Preparation STEPS 1-3]… Refers to the creation of this Learning Plan, by the two teachers in collaboration. **STAGE II**: Action Plan Formulation [Development STEPS 4-14, 16-17]… Refers to the realization by the students of the six activities of the Learning Plan. **STAGE II**: Action Plan Formulation [Completion STEPS 15, 18]… Refers to the evaluation by the teachers [15], and the presentation by the students of their results [18].
3. Objectives and Methodologies	
Learning Goals and Objectives	By the end of the L&C Plan, students should *define* and *calculate* (in euros): • total revenue • total fixed costs • total variable costs

	• total costs • average total costs • profit
Learning Outcomes and expected Results	After the project, learners will be able to investigate the market and become more competitive using new technologies. This procedure develops their critical mind and fosters their curiosity about new markets and about their future as entrepreneurs. Their communicative skills and their ability to collaborate will be enhanced, as they will be obliged to make decisions as partners. The result will be the virtual e-shop with the aid of spreadsheet for billing and pricing the product.
Prior Knowledge and Prerequisites	Basic knowledge of mathematics and spreadsheet document, global market perception (comparing prices and features)
Motivation, Methodology, Strategies, Scaffolds	The main methodologies and techniques of the course are based on inquiry-based learning. In this way, students are encouraged to explore the material, prioritize data, ask questions and share ideas. Inquiry-based learning uses different approaches to learning, including small-group discussion and guided learning. Students are involved in designing and conducting their own scientific research after having some queries and case studies. Specifically, students learn by making their own e-business, instead of memorizing facts and material. This allows them to build knowledge through exploration, experience and discussion. In addition, students get the chance to explore economic terms more deeply and learn from their own first-hand experience. Students have the opportunity to investigate a problem and find possible solutions, make comments and questions to test ideas, think creatively and use their intuition. As they explore this Learning Plan, students build critical thinking and communication skills. The cognitive skills that students develop can be used to improve comprehension in every subject, as well as in day-to-day life. Last but not least, team working and brainstorming can get the student on the path to success.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	A free design platform of the Internet will be the basic tool and with the use of spreadsheet document, students will make the appropriate calculations for the final pricing of the product. Tablets and laptops in the classroom, will be necessary for students, in order to investigate the market and of course to develop their e-business. According to lesson activities students could work or individually or in groups of 4-5 students or in plenary session.
Resources, Tools, Material, Attachments, Equipment	• "The logo Game" application: apps.apple.com/us/app/logo-game-quiz/id953721694 • Infographic "Fixed vs Variable Costs": napkinfinance.com/napkin/fixed-cost-vs-variable-cost • Calculation of the profit: news.wtm.com/wp-content/uploads/2016/12/Profit-Feature.jpg • Kahoot: kahoot.it/ • e-Shop creation: https://www.shopify.com
Safety and Health	
5. Implementation	
Instructional Activities, Procedures, Reflections	The plan can be completed in four learning hours, the two first hours with 5 activities related to the understanding and analyzing the billing of a product and the two second hours with one activity, which is the creation of their own e-business.

1. Brainstorming (20 minutes)

First of all, students are divided into groups of 4-5 persons. The teacher gives them a worksheet without explain anything or analyze the economic terms. With the help of the following infographic, students will try to answer the questions.



2. Game for finding the well-known logos (5 minutes)

Students play with "The Logo Game" application that shows various images of business logos (or parts of logos) and ask users to identify each business.

3. Playing with quizzes about the six terms (15 minutes)

Students working either individually or in small groups, play a Kahoot quiz-game prepared by the teacher. They try to answer multiple choice questions on the 6 economic terms without being taught it, with what they have understood from the first activity.

	4. Definition of the economic terms (30 minutes) Teacher's presentation and plenary discussion, based on students' findings of the previous activities, defines the terms: costs, average costs, revenues and profit. The correlation with examples from real life is important and helpful. Through calculations and small case studies, students answer 5 multiple choice questions in the end of the presentation.  **5. Case study (20 minutes)** In the end of the first lesson, students will summarize their knowledge via the worksheet, as a case study. This case study will help them to organize the data (table) and apply all the terms that they have already learned. The questions, based on the STEAME investigative approach, develop their critical minds. **6. Creation of the e-shop (90 minutes)** As far as the application of this activity is concerned, students will separate in groups and every group will choose the product or the service which it wants to produce and promote. They are going to investigate the market, to locate suppliers and learn about similar businesses (competitors). The creation of the e-shop has been implemented via PowerPoint Presentation or via the free Platform ''shopify''.
Assessment - Evaluation	▪ A *self-assessment* with immediate results, is the Kahoot game (activity 3). ▪ A *group-assessment i*s the multiple-choice questions and the small case studies in the end of the Teachers' Presentation (activity 4). ▪ An *evaluation using a rubric with four criteria*, is the worksheet submission (activity 5). Apart from their ability to perceive and apply the economic terms, we can monitor their collaboration skills, during the above two activities.
Presentation - Reporting - Sharing	A presentation by each group takes place as an extra activity (an additional 20-minute lesson), analyzing the steps from the billing until the pricing of the product. Students should present all the variables that take into consideration in order to complete the e-shop.
Extensions - Other Information	Event - real meeting with executives of a big firm with well-known products and on a call (via teleconference or face to face) and with a businessman whose main activity is organizing and running an e-shop.

STEAME 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)

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

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

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

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

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

Review (by teachers)

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

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

20. Repeat steps 5 through 11 with additional or new requirements as formulated in 15
21. Investigation - Case Studies - Expansion - New Theories - Testing New Conclusions
22. Presentation of Conclusions - Communication Tactics.

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

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

LEARNING & CREATIVITY PLAN (L&C PLAN): THE CREATION OF MY ADVERTISEMENT

S	*T*	*Eng*	*A*	*M*	*Ent*
☐	☒	☐	☒	☒	☒

1. Overview

Title	THE CREATION OF MY ADVERTISEMENT
Driving Question or Topic	WHAT I NEED TO KNOW ABOUT THE FACTORS THAT MAY SHIFT THE DEMAND CURVE?
Ages, Grades, …	AGES:15-16 9^{th} - 10^{th} grade
Duration, Timeline, Activities	4 LEARNING HOURS 2*90 MINUTES 6 ACTIVITIES
Curriculum Alignment	FACTORS THAT AFFECT THE DEMAND FOR A PRODUCT
Contributors, Partners	
Abstract - Synopsis	Five activities for two learning period of 90 min (first lesson) include the analysis and the understanding of several factors that may actually affect the demand for a product or a service, negatively or positively. So, for these reasons, in the second period of 90 min (second lesson), every group of students designs and creates an advertisement in order to promote a product of their choice. This is a well-known method to increase the demand for it. In this way, they understand the mechanism of the market in action.
References, Acknowledgements	• Pearson Edexcel International GCSE (9-1) Economics - Case Study (Lesson 4): Holiday Treat (activity 1)

2. STEAME Framework

Teachers' Cooperation	1st Teacher: Economist 2nd Teacher: Teacher of Art (the two teachers can work together during the second lesson)
SiL Organization	A real meeting (via teleconference or face to face) with an executive who is specialized in the field of marketing.
Action Plan Formulation	**STAGE I**: Preparation by two teachers [STEPS 1-4], and **STAGE II**: Action Plan Formulation [Preparation STEPS 1-3]… Refers to the creation of this Learning Plan, by the two teachers in collaboration. **STAGE II**: Action Plan Formulation [Development STEPS 4-14, 16-17]… Refers to the realization by the students of the six activities of the Learning Plan. **STAGE II**: Action Plan Formulation [Completion STEPS 15, 18]… Refers to the evaluation by the teachers [15], and the presentation by the students of their results [18].

3. Objectives and Methodologies

Learning Goals and Objectives	By the end of the L&C Plan, students should define and analyze the factors that cause a shift in the demand curve: • income • fashion and tastes • price of substitutes

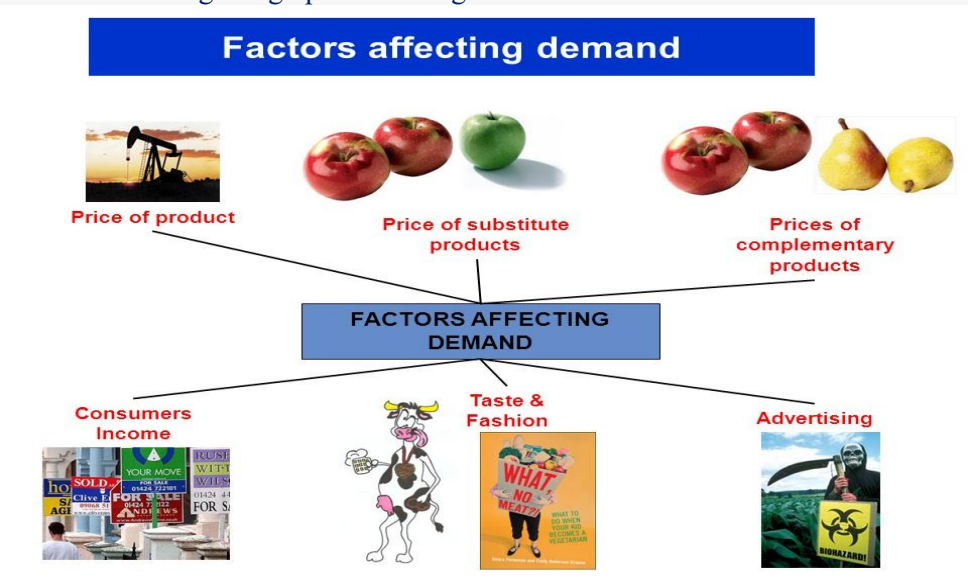
	• price of complements • demographic changes • advertising
Learning Outcomes and expected Results	After the project, learners will be able to investigate the market and become more competitive using marketing techniques and strategies. This procedure develops their critical mind and fosters their curiosity about new methods of expansion. Furthermore, students will comprehend the correlation with substitute and complementary goods. Their communicative skills and their ability to collaborate will be enhanced, as they will be encouraged to make decisions as partners. The result will be the creation of an advertisement as an effective and well-known method, which affects the demand for a product positively.
Prior Knowledge and Prerequisites	Basic knowledge of mathematics and the ability to decode the diagrams retrieving all the relevant information. Global market perception (impact of advertising on consumer's behavior, how the income affects the decision of a consumer).
Motivation, Methodology, Strategies, Scaffolds	The main methodologies and techniques of the course are based on inquiry-based learning. As a matter of fact, students are encouraged to explore the material, prioritize data, ask questions and share ideas. Inquiry-based learning uses different approaches to learning, including small-group discussion and guided learning. Students are involved in designing and conducting their own scientific research after having some queries and case studies. Specifically, students learn by making their own advertisement, instead of memorizing facts and material. This allows them to build knowledge through exploration, experience and discussion. In addition, students get the chance to explore economic terms more deeply and learn from their own first-hand experience. Students have the opportunity to investigate a problem and find possible solutions, make comments and questions to test ideas, think creatively and use their intuition. As they explore this Learning Plan, students build critical thinking and communication skills. Last but not least, team working and brainstorming can get the student on the path to success.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	Tablets and laptops in the classroom, will be necessary for students, in order to investigate the market and of course to develop their advertisements. According to lesson activities, students could work or individually or in groups of 4-5 students or in plenary session. The need of A3 sheets will be an important tool in order to categorize the factors that affect the demand for their product. During this procedure, if one group want to ask a question, then a representative of the other group could help.
Resources, Tools, Material, Attachments, Equipment	• Padlet created by the students: https://padlet.com • "The logo Game" application: https://apps.apple.com/us/app/logo-game-quiz/id953721694 • Infographic for the six factors that affect the demand curve (searching for a relevant image). • Kahoot created by the teacher: https://kahoot.it • Video for the factors that affecting demand: https://www.youtube.com/watch?v=Enz6z9jGmsk
Safety and Health	
5. Implementation	
Instructional Activities, Procedures, Reflections	The plan can be completed in four learning hours, the two first hours with 5 activities related to the understanding and analyzing the factors that affect the demand curve and the two second hours with one activity, which is the creation of their own advertisement.

1. Brainstorming (15 minutes)

This activity help students to understand how much existing knowledge they have – perhaps without even realizing they have it. In 4 or 5 different workstations around the room; each station should have an A3 piece of paper with a factor that may cause a shift in the demand curve written on it. Specifically, each station writes down everything they know about that factor. For example, they could:

a) define it in their own words
b) explain its impact on demand
c) give examples of this type of factor
d) write down where they have seen it before
e) write down the price of it.

The following infographic will be given for their convenience.



2. Game for finding the well-known logos (5 minutes)

Students play with "The Logo Game" application that shows various images of business logos (or parts of logos) and ask users to identify each business.

3. Playing with quizzes about the six factors (15 minutes)

Students working either individually or in small groups, play a Kahoot quiz-game prepared by the teacher. They try to answer multiple choice questions on the 6 factors that affect the demand for a product without being taught it, with what they have understood from the first activity.

	4. Factors that affect the demand for a product (30 minutes) Teacher uses PowerPoint presentation in order to introduce the students to the six factors affecting demand for a product. Teacher explains how each factor will cause a shift in the demand curve and ensures students understand how this is different to the effect of changing prices (which cause a movement along the demand curve). Furthermore, she provides real world examples to illustrate each factor. At the end of PowerPoint, a video will be shown and a case study will be discussed and answered by the students. **5. Demographic changes as a factor of demand (25 minutes)** Students choose an area (e.g. closest city/country) and create a presentation describing/explaining how the demography has changed the demand for certain products in that area. This homework is much more challenging and more appropriate for students who need a challenge. Students who need more support could be given sentence starters/page titles hinting at what to include (e.g. a specific area, a specific product, etc.) **6. The creation of advertisement per group (90 minutes)** Students will separate in groups and every group will choose the product that they want to promote. Advertising requires making your product appear appealing to a potential consumer. So, the process of creating an effective advertisement in six simple steps is the following: 1. Students are going to investigate the market and compare other advertisements from similar companies (competitors) 2. Focus on a specific target group 3. Learners start to think about the headline and work on the body or the main text. 4. The creation of a slogan plays a vital role in the effectiveness of their advertisement. 5. Each group draw the graphics in collaboration with the teacher of Art. This collaboration will be beneficial in order to develop an up-to-date project with modern practices. 6. Finally, they have to choose where to advertise their product. After this procedure, every group will make a presentation of their advertisement. With the help of padlet, every group can make comments for the other groups, as a game. At the end, a voting takes place for the best and smartest advertisement.
Assessment - Evaluation	▪ A *self-assessment* with immediate results, is the Kahoot game (activity 3). ▪ A g*roup-assessment via the* case study in the end of the Teachers' Presentation (activity 4). ▪ Peer assessment via advertising (activity 6), where every member of the group tries to influence other members through innovative ideas and effective promotional practices. Padlet is a way to enhance this procedure, as every group can make specific comments for the rest advertisements.
Presentation - Reporting - Sharing	A presentation by each group takes place in the final activity, analyzing the steps from the choice until the development of their own advertisement. Students should present all the variables that take into consideration in order to complete the advertisement.
Extensions - Other Information	Every student could observe household products and perceive the way that every company promote and advertise them.

STEAME 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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

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

LEARNING & CREATIVITY PLAN (L&C PLAN): ROAD SAFETY

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☒	☒	☒	☒	☒

1. Overview	
Title	Road safety
Driving Question or Topic	*How much do safety systems affect in reducing the consequences of road accidents?*
Ages, Grades, …	16 – 18 *K-11*
Duration, Timeline, Activities	*25 learning hours* *25x45minutes* *6*
Curriculum Alignment	Physics of collisions, Statistical Data Processing, Car Safety Systems, Poster Creation, Video Creation
Contributors, Partners	
Abstract - Synopsis	*The students are involved in a multifaceted investigation of the issue of road safety. They are concerned about a social phenomenon and try to act as active citizens and utilize scientific knowledge to suggest ways to alleviate the problem of road accidents.*
References, Acknowledgements	
2. STEAME Framework	
Teachers' Cooperation	• *Teacher 1 (T1) - Teacher of Physics* *Formulation of the topic, bibliography study, teaching of the Physics of collisions, coordination of groups.* *Physics Laboratory.* • *Teacher 2 (T2) - Teacher of Mathematics, Statistics, Research Methodology* *Teaching methods of data collection, construction of appropriate questionnaires, methods - sampling techniques, methods of checking the validity of the questionnaire, coding of questions and answers, methods of statistical analysis and presentation of results.* *Classroom.* • *Teacher 3 (T3) - Art teacher.* *Poster design guidance.* • *Teacher 4 (T4) – Theatrology teacher* *Guidance on creating a video clip script for road safety.* • *Teacher 5 (T5) - Teacher of Economics* *Teaching the costing process of a service (creating specifications, market research, creating a budget for the service).* • *Teacher 6 (T6) - Teacher of Computer Science* *Teaching the construction of electronic questionnaires (e.g. Google Forms) or data entry (in Excel Spreadsheet or other Data analysis software).* *Teaching methods of statistical analysis and graphical presentation of results (using Excel).* *Support for converting the poster to electronic format and creating the video clip.* *Computer Lab .*
STEAME in Life (SiL) Organization	*Road safety is an issue that all people face in their daily lives. In their investigation, the students will deal with data that they will collect themselves and data that they will receive from competent bodies (eg Police). They will try to raise public awareness of road safety issues by creating posters and videos.*
Action Plan Formulation	*STAGE I: Preparation by T1 and T2 [STEPS 1-3], and* *STAGE II: Formulation of an Action Plan [Preparation of STEPS 1-2]*

	Refers to the creation of this learning plan, by teachers in collaboration. *STAGE II: Formulation of an Action Plan [Implementation of STEPS 3-11] …* *Refers to the realization by the students of the activities of the Learning Plan. The support, feedback and evaluation by the teachers is present during the implementation of the activities and not only the final result.* *STAGE II: Formulation of an Action Plan [Implementation of STEPS 3-11] …* *Refers to the realization by the students of the activities of the Learning Plan.* *STAGE II: Formulation of results by students and guidance by teachers (STEPS 12-14). Intermediate control by teachers and feedback to students (STEP 15)* *STAGE II: Repeat steps 5 - 11, if necessary, draw final conclusions and communicate them (STEPS 16 - 18).*
3. Objectives and Methodologies	
Learning Goals and Objectives	*1. To plan and carry out experimental activities for investigation:* *• the role of the seat belt in a car* *• the role of the airbag in a car* *• the dependence of the braking distance of a car on its speed* *2. Collect and record data using various methods, such as observation, measurement / recording* *3. To process statistical data and correlate variables.* *4. Understand the role of the active citizen.*
Learning Outcomes and expected Results	*1. Experimental data on the force exerted on a body during impact on a surface and in an airbag as a function of the velocity of the body during impact.* *2. Experimental data for the vehicle braking distance as a function of vehicle speed before braking.* *3. Experiment video on the role of the seat belt in a car.* *4. Questionnaire to investigate the views of a specific population on road safety issues.* *5. Poster for raising community awareness on road safety issues.* *6. Video clips to raise community awareness on road safety issues.* *7. Economic study on the cost of a measure to improve road safety (eg installation of cameras in traffic lights).*
Prior Knowledge and Prerequisites	*1. Basic knowledge of descriptive statistics and use of spreadsheets (excel).* *2. Knowledge of using motion and power sensors* *3. Basic knowledge of design program in computer.*
Motivation, Methodology, Strategies, Scaffolds	*Inquiry based learning approach, working in groups with collaborative learning. The surveys given by the teachers are open and the students are invited to design the ways of conducting these surveys. Teachers intervene when students have difficulty planning investigations or have not considered all aspects of the problem*
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	*The teaching of the basic concepts of Physics of collisions and statistical analysis will be implemented by T1 and T2 in the classroom. Experimental investigations are carried out in the Physics laboratory. The electronic questionnaire design can be done either in the computer lab under the guidance of the T6, or in non-school time with the support of the T6. Communication with agencies that can provide information on road safety can be done through the school unit.*
Resources, Tools, Material, Attachments, Equipment	*• For the role of Physics in road safety and for exploration ideas* o https://www.scienceinschool.org/content/look-out-physics-road-safety o https://www.mynrma.com.au/-/media/documents/motoring-education/study-guides/nrma-the-road-safety-total-learning-resource-years-9-10.pdf?la=en o https://www.sci-ed-ga.org/staying-alive o https://roadsafety.scot/wp-content/uploads/2017/08/Neale-Kinnear-Changing-speed-limits-Implications-for-road-safety.pdf o https://www.youi.com.au/youi-news/road-safety-week-the-physics-of-speeding o https://learn.teachingchannel.com/video/8th-grade-science-motion o http://www.fisme.science.uu.nl/toepassingen/28754/

Safety and Health	*• Data collection methods - Sampling methods and techniques - Construction and use of appropriate questionnaires (paper or electronic) - Methods of checking the validity and reliability of the questionnaire (use of appropriate software) - Methods of statistical analysis and presentation of results - use of results (use of appropriate results) detailed research report* *Links to the Learning and Creativity Plan of the STEAME program "Research–Services Evaluation"* *• Physics laboratory with cars, motion and force sensors.* *• Computers with video design and editing programs* *• Collection of information on the number of road collisions and their characteristics* *o Traffic departments of the Police or the municipality*
5. Implementation	
Instructional Activities, Procedures, Reflections	*The L&C plan can be implemented in 25 periods. In the 1st period, T1 and T2 discuss with the department and through an ideological storm record the aspects of road safety that need to be investigated. T1 and T2 guide the class, if necessary, indicating factors not mentioned. Then the actions that the groups will deal with are divided, with some actions, directly related to the syllabus being common to all groups. The course of the group work, the collaboration with the other teachers, the way of receiving feedback and the method of evaluating the work of each group are determined. Students are invited to study the material at the links mentioned above for road safety.* ***1. The Physics of Impacts (4 periods)*** *T1 teaches the Physics of collisions and instructs teams to design and perform experimental activities to explore the following:* *• The force exerted when a body hits a hard surface (car dashboard) and a soft one (airbag).* *• What will happen to a car passenger in a road collision, if he/she has not put on a seat belt.* *• How the braking speed of a vehicle changes relative to the vehicle speed before braking. How does this distance depend on the condition of the road.* *Each group undertakes to investigate one of the above factors and presents to the plenary the results of the investigation.* ***2. Collection, statistical processing of data and their presentation. (6 periods)*** *T2 and T6 help students to collect data on the views of a certain group of people (e.g., schoolchildren) about the causes of road accidents and how to reduce them and, at the same time, to obtain data from the competent authorities on road collisions and their causes.* ***3. Design a poster to raise public awareness about road safety. (3 periods)*** *T3 guides teams in theme selection and poster design. Each group can deal with a different issue of road safety (e.g., use of seat belt, observance of the speed limit, avoidance of driving under the influence of alcohol, non-use of mobile phone while driving, etc.)* ***4. Costing of a measure to improve road safety. (3 periods)*** *With the help of the T4, the teams undertake to cost the implementation of a measure, which will improve road safety (e.g., installation of cameras at road junctions, continuous surveillance of motorways to exceed the speed limit, withdrawal of cars without airbags, etc. a.).* ***5. Creating a script for video clips for road safety (4 periods)*** *T5 guides teams to create a common road safety video clip. Each group can contribute material from the actions they have already carried out.*

	6. Presentation of results - Preparation of a detailed research report (4 periods) *Each group prepares a presentation with the results of the actions it has implemented. The groups turn to the teachers for help, depending on the action. T1 – T6 provide ongoing support, feedback and evaluation.*
Assessment - Evaluation	*The feedback and evaluation is continuous throughout the actions until the presentation of the results.*
Presentation - Reporting - Sharing	*The presentation of the results can be done for the student community of the school, but findings from the research of the groups can be communicated to competent bodies of the community (e.g., Municipal Council, Police, etc.).*
Extensions - Other Information	The work of the class can be the beginning of a more general effort to raise the awareness of the entire student population and the community on road safety issues in collaboration with relevant bodies.

STEAME 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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

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

LEARNING & CREATIVITY PLAN (L&C PLAN): STEAME in the work of entrepreneurs, scientists, artists

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☒	☒	☒	☒	☒

1. Overview	
Title	Research on the STEAME aspects in the work of entrepreneurs, scientists, artists – case studies by Leonardo da Vinci and Elon Musk (Tesla)
Driving Question or Topic	What are the key success factors that I can identify, analyze and
Ages, Grades, …	**Ages 13-18** **7th - 12th grade**
Duration, Timeline, Activities	24 learning hours 36*40 minutes 1 project/team
Curriculum Alignment	Entrepreneurship classes in 10th grade
Contributors, Partners	
Abstract - Synopsis	Students are divided in teams of 4-5 in their classes of Entrepreneurship and do research on the work of Elon Musk (Tesla) and Leonardo da Vinci. All teams present final results in their presentations with key conclusions and analysis of the success factors. The main approach, applied in the process is using the inquiry-based learning based on the study of cases for interdisciplinary scientific, social, project and business realizations, as in addition to gather and analyze the necessary information, in order teachers and students to identify disciplinary and interdisciplinary links with studied, in previous periods or at present, subject areas. The following scientific areas are included in the research project of teachers and students - Mathematics; Arts; Physics; Chemistry; Biology; Anatomy.
References, Acknowledgements	
2. STEAME Framework	
Teachers' Cooperation	**Teacher 1** is the main teacher – in Entrepreneurship and Economics who works in cooperation with the other teachers: in Science (Chemistry and Physics), Technology (IT, Computer Science), Math, Arts. T1 provides the workplan and main tasks for all teams starting with the division of teams and assigning one topic to each one of them: Science, Technology and Engineering, Arts, Math, Entrepreneurship.
STEAME in Life (SiL) Organization	**Teacher 2 is in Science – Chemistry, Biology, Physics.** Teaching scientific elements and topics and guidelines for students how to conduct scientific research, bibliography quotations, **references**, credible sources of information. T2 mentors one team and supports the project work with questions and particular tasks aligned with the main plan and workflow provided by T1. **Teacher 3 is in Computer science/IT** T3 mentors one team working on the topic Technology and Engineering. S/he also supports the teams with necessary knowledge and skills for: research and data collection via surveys online, forming questionnaires, analysis of data, preparation of presentations with different software – PowerPoint, Prezi, Storyboardthat, videos, comix, digital storytelling and other tools.

	Teacher 4 is in Math and s/he also mentors a team of students who do research in the mathematical aspects of work of the entrepreneur/scientist/artist. S/he also teaches how to analyze data, use mathematics and statistics including preparation of the final presentations – e.g., analysis and diagrams, preparation of spreadsheets in MS Excel, etc. **Teacher 5 is in Arts** and provides mentorship and guidelines in terms of the aspects of arts.
Action Plan Formulation	**Stage 1** is preparatory actions by the teachers who work together led by the main teacher T1 who develops sample workplan with tasks, deadlines and topics aligned according to the curriculum of 10th grade. At this stage the assessment methodology is also developed – criteria and way of assessing students' work including self-assessment. Students are divided into teams and each one has a specific topic of STEAME to research and analyze. If here are two classes of 10th grade a different project is assigned – e.g., one for Leonardo da Vinci, one for Elon Musk, etc. **Stage 2** is the implementation when students start their work with introduction to the topics and all teachers work in their classes and online to mentor the students with specific questions. Throughout the classes students research and analyze different case studies, i.e. the work of the person (Leonardo da Vince, Elon Musk, etc.) and provide examples. **Stage 3** is **finalization** when all teams prepare their final presentations in the Computer science/IT classes and **Stage 4 is evaluation** of the work. Each teacher follows the aligned evaluation methodology, i.e. evaluates the teamwork, the research and knowledge, the presentation and communication skills of students.
3. Objectives and Methodologies	
Learning Goals and Objectives	Upon completion of the class students should **know**: - What the application of science in real work of certain successful person is - How important interdisciplinary approach is - How important teamwork is - What is project work and how to lead and implement it - Main terminology and key theoretical concepts in STEAME They should **be able to** - Work in teams and lead/follow the leader - Cooperate with their teachers in the relationship mentor-mentee - Conduct scientific research - Provide references - Analyze data and prepare diagrams, graphs, Excel tables, etc. - Prepare presentations and digital storytelling - Apply creativity and generate new ideas - Communicate in the team and in front of audience
Learning Outcomes and expected Results	Expected **results**: - Presentations with storytelling elements/videos/comix, etc. - Analysis and research results - Final conclusions - Real application of the topics taught in their science classes
Prior Knowledge and Prerequisites	Maths and IT – Excel, presentation skills with PowerPoint, work with MS office, research and analysis.
Motivation, Methodology, Strategies, Scaffolds	The main differentiator in this Plan is the new role of teachers T2-T5 who guide and support the student teams on their work. Other approaches applied in the process are project- and inquiry-based learning. Under the new conditions of Covid-19 it can be easily adapted and be implemented as blended learning with flipped learning elements. This is another innovative approach, used in the project which is a type of blended learning where students are introduced to content at home and practice working through it at school. This is the reverse of the more

	common practice of introducing new content at school, then assigning homework and/or project to be completed by the students independently at home[3]. The plan allows individual work by each student when doing their research and the team leader could divide the case study/topic into sub-topics for each team member, then team analysis and findings followed by preparation of the team presentations, videos, stories, etc. Thus it is a multi-modal approach and allows flexibility based on the student's learning style.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	There is one leading Teacher 1 who is in Economics and Entrepreneurship field. T1 leads the process as the classes are organized around the STEAME projects aligned with the topics of studies in science, computer science/IT, Arts, Math. There are classes taught in the Labs – science, arts, IT ands students work there. All student teams should have at least one PC/laptop/desktop. In addition teachers provide also online support in the mentoring process according to a work plan.
Resources, Tools, Material, Attachments, Equipment	Tools to be used: - MS office – Word, Excel, PowerPoint, mind maps, analytical tools, - Citation Guide (https://libguides.dixie.edu/) - Digital storytelling: www.storyboardthat.com , www.powtoon.com , www.pixton.com, www.canva.com, etc. - Mind maps – www.miro.com, www.mindmup.com, www.mindmeister.com , venngage.com, etc. - communication and collaboration platform - Google Meet, Google Classroom, Zoom, Skype, etc. - e-learning platform – Google classroom
Safety and Health	
5. Implementation	
Instructional Activities, Procedures, Reflections	This Plan is developed around the school classes from elective school subjects as the leading teacher/class. It covers: i. Information Technology ii. Entrepreneurship iii. Market economy (Economics) iv. Starting your own business v. Entrepreneurial management vi. Marketing vii. Finance viii. Presentation and communication skills The other teachers/subjects from the i. Teachers plan their activities on Google Calendar as part of the curriculum. T2-T5 follow their regular plans and includes examples and information and activities based on the main case study – e.g. the work of Leonardo da Vinci, Elon Musk, etc. Students are actively engaged through hands-on experience and research conducted as homework assignments which are then discussed in class. Each team has a mentor according to their assigned aspect/topic, i.e. *Technology and engineering in the work of Leonardo da Vinci, etc.* The planned **24 learning hours** are based on a class of 40 minutes. **The lead teacher, T1** is engaged in all his/her classes in one school year, i.e. 36 classes of 40 minutes each. - 4 hours introduction and preparation - followed by 12 hours – implementation - 4 classes work on presentations and video making - 4 hours final presentations and feedback sessions. T2-T5 align their activities with the implementation within 8 learning hours including 4 learning hours guidelines of T3-4 how to analyze data, develop diagrams/graphs and online surveys (Google forms, Survey monkey, etc.).

[3] https://www.teachthought.com/learning/the-definition-of-the-flipped-classroom/

	Teachers could be less with key success factor – to be fully aligned and agree on the timeline, sequence of activities, tasks and evaluation of the teams. Their number is defined by the STEAME fields that are covered. This should be defined prior to the school year. If the project is done for the first time it is a good idea to have few teachers and organize a pilot testing so that students and teachers provide feedback and adjust to the new way of teaching and learning. Classes can be done simultaneously and/or in consequence and parallel based on the practice at school and the weekly schedule of classes. It is easier in distance learning and the process allows for after-school brief sessions. Teachers provide general information, guidance and instructions during classes to all teams and then they work individually on the specific tasks, activities and content tailored to their topic/s. The process allows also competition and rewards for the final results/presentations to motivate students further.
Assessment - Evaluation	**The evaluation** is done on the following scale: - Self-assessment by team members (reflects the degree of critical thinking of each team member): from 0 to 100%, depending on the % of the total result achieved as an individual contribution - Team assessment by the team leader and the teacher: (reflects the opinion of the team leader and the teacher about the work of each team member described in "Criteria for evaluating the individual and team contribution of the participants in STEAME and project-based training (points 1 to 9)": from 0 to 100%, depending on the% of each contribution to the overall team result which is based on team and peer evaluation based on the roles in the team. Criteria could be: active participation in meetings, completion of tasks, meeting deadlines, fulfillment of the quality criteria, final presentation and use of videos and other digital storytelling, creativity is a key aspect in the process. - Teacher's assessment in the respective discipline: (assessment of performance - individual and team plus current assessment): from 0 to 100%, depending on the individual and team result - Jury rating (depending on the ranking): from 0 to 100% - Bonus assessment (set at the teacher's discretion: from 0 to 100%) based on outperformance and meeting the quality and complexity criteria – if the research and results are profound and beyond what teachers taught students, including creativity.
Presentation - Reporting - Sharing	Case studies and the respective projects of students can be developed as follow: Case study **Leonardo da Vinci** - *Scientific research, engineering and technological inventions and ingenious achievements in the fine and graphic arts of Leonardo da Vinci* - *The Golden Ratio and Leonardo's* - *Paints now and then* - *Differences between Da Vinci's drawings and contemporary anatomy* Case study **Elon Musk** - *Science and technology behind the entrepreneurial success of Elon Musk* - *Elon Musk – the explorer and scientist* - *Arts and solar energy* - *The engineer Elon Musk*
Extensions - Other Information	Based on the expertise and field of studies of the teachers who participate in the process the cases could be different and based on best practices about companies in science, engineering, math, arts, etc. and/or famous people in these fields. It is good to give students cases that are familiar to them. If decided students can choose the case by themselves following a common guidance what is and what is not included in this type of project-based learning. Teamwork, creativity and as many aspects of STEAME are key success factors.

STEAME 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:
    a. Key success factors and traits of successful entrepreneurs, artists, scientists
    b. Research and analysis of data
    c. Presentation and communication skills, tools and methods
    d. Digital storytelling
    e. Preparation of online surveys and questionnaires
    f. Ethics of science
    g. Business development and growth
    h. Science, technology and engineering in business creation and development

2. Engaging the world of the wider environment / work / business / parents / society / environment/ ethics
   The project- and inquiry-based learning is organized around real case studies and best practices that are familiar to students – i.e. famous scientists, entrepreneurs, including local ones who can be involved in the process with interviews, brief presentations, discussions, participation and evaluation at the final presentations, etc.

3. Target Age Group of Students - Associating with the Official Curriculum - Setting Goals and Objectives
   The plan allows for involvement of students in Grades 8-12.

4. Organization of the tasks of the parties involved - Designation of Coordinator - Workplaces etc.
   T1 is the teacher in Entrepreneurship, Business, Economics areas. S/he provides the main case study/topic of work of the students and provides organizational guidance to the other teachers T2-T5 including strict workplan, tasks and monitoring. The classes can be done both online and in the classroom.
   T2 is teacher in Science – Biology, Chemistry, Physics – providing mentorship to one student team who work on the science aspects/sub-topics and provide knowledge about the specific examples, analysis of the work of the person assigned, including terminology and theory to be considered in the research; bibliography, citation rules and sources of credible information; guidance for analysis of data. Classes are conducted in the Science Lab.
   T3 is teacher in Computer science/IT fields who works closely with the **T4 in Mathematics**. They prepare students how to conduct research, analyze data, use Excel incl. formulas, diagrams/graphs, online surveys and questionnaires, etc. for statistical analysis and presentations. T3 and T4 conduct classes in the Computer lab.
   T5 is the teacher in Arts who provide mentoring and guidance related to the aspects of arts and the artistic, design and other related elements. T5's classes are in the Arts Lab.
   Teachers 2-5 have the main role of mentoring and they are engaged both in their regular classes in the classroom, and after class work – online via email and other**.** In the preparation stage they organize their classes and include interdisciplinary elements with particular examples, cases, exercises for homework and additional tasks for the teams.

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

Preparation (by teachers)

1. **Relation to the Real World – Reflection**
   Students are engaged in a project to apply their knowledge and skills in the real world examples. It is always a good idea to apply role models, famous people/"rock stars" whose life and work are successful.

2. **Incentive – Motivation**
   Students work in teams of 4-5. According to the criteria they can compete for the first place. They receive additional recognition by the T1 and/or the school as Certificates, extra-curricular work they conduct, etc. This L&C Plan allows for organization of final competition among all teams and/or different classes.

3. **Formulation of a problem (possibly in stages or phases) resulting from the above**
   Defining the main case study can be defined either by the group of teachers 1-5 involved in this plan and/or by the students themselves. It is necessary to define criteria for selection – e.g., popularity, success, performance, innovative products/services, paintings, sculptures, interesting facts, etc. It needs to be interesting and appealing to students and their age. Students in general are more creative, they look for information online via different channels/platforms/media and can define the case study themselves, guided by their teachers. This however should be a well-structured and guided process as they work in teams and the topic should allow division of sub-topics in Science, Technology, Engineering, Arts, Math, Entrepreneurship.

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

4. **Background Creation - Search / Gather Information**
   Students learn about the key success factors and concepts of work, incl. entrepreneurship and business creation. The main information is taught in class and then additional research is conducted online and via interviews (if and when possible). The role of all teachers and teach them how to find the credible sources, how to evaluate and analyze data, how to develop insights and drive final conclusions to develop presentations.

5. **Simplify the issue - Configure the problem with a limited number of requirements**
   After the initial definition of the case study and the main topic/best practice for the work of students each teacher defines more specific sub-topics which are then assigned to one team – thus there are at least six teams of 4-5 students within the following aspects/sub-topics:
   - Science
   - Technology
   - Engineering
   - Arts
   - Mathematics
   - Entrepreneurship

   The definition is broad enough to give freedom to students to develop their own research plan and main goals. The minimum requirements are related to the development of: online survey, desktop research, processing of the survey results, visualization of key findings and driving conclusions. All of the above is structured in a presentation.

6. **Case Making - Designing - identifying materials for building / development / creation**
   All student work in teams. T1 provides general guidance and introduction to the projects in the first 2-3 classes in subject Entrepreneurship. Teams are formed by students and mentored by teachers 2-5 who provide in-class and extracurricular distance support. All teams follow the same working process but in different sub-fields: preparation on the subject, initial desktop research, online survey, analysis of survey results, further research, preparation of a presentation and video.

7. **Construction - Workflow - Implementation of projects**
   During the implementation of projects students follow their action plans approved by the mentors and the main teacher T1. Each plan should include desktop research, collection and analysis of responses to online survey, key conclusions and insights presented in final team presentations. The main content is developed within the sub-area defined at the introduction and preparatory stage.

8. **Observation-Experimentation - Initial Conclusions**
   Student teams conduct small-scale experiments in their STEAME classes, together with exercises, examples and theory. Students observe the processes and main concepts, then generate their own research which includes desktop research and online surveys. Depending on the case study defined it may include also conducting focus groups with peers and partners as well as interviews. Final results are accumulated and visualized in a presentation and a video/story.

9. **Documentation - Searching Thematic Areas (STEAME fields) related to the subject under study – Explanation based on Existing Theories and / or Empirical Results**
   Students and mentors work together to validate the findings of the research. The models that are used for data analysis and main findings for the final presentations are aligned with the studies in 10th grade. Most common tools are based on MS Excel with focus on visual representation and use of graphs. In terms of science, simple experiments and knowledge are applied so that students can draw conclusions for the application in real life and work related to the case study they are working on. The method of flipped classroom can be applied here as students work at home to review the theoretical content and then discuss in class and/or in their teams and ask relevant questions for further clarification and application in their projects.

10. **Gathering of results / information based on points 7, 8, 9**
    The main challenge in gathering accurate results is the source of information and the target groups for the online questionnaires that are distributed mainly in the existing networks in social media of students and mentors. Part of the process is the credibility of the source for the desktop research, which is covered by all teachers and mainly the ones who teach science. They provide guidance and monitor the process – e.g., what is the average age, area of expertise, geographic area, gender, etc.

11. **First group presentation by students**
    There are several presentations which mark the milestones in the work of the teams:
    - One for the findings of the desktop research
    - One based on the online surveys and the collection of answers, analysis and visualization.
    - Semi-final

    Important part is the synthesis of all information and the ability to prepare graphs and comparisons – e.g. technologies and processes in the past and present days. Another important aspect is the impact on business development when working on case studies of entrepreneurs.

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

12. **Configure mathematics or other STEAME models to describe / represent / illustrate the results**
    Besides mathematical/statistical and scientific models, the presentations and analysis should include some financial analysis in terms of costs, revenue, profit and financial forecast. This is covered in the special subjects like Economics and Entrepreneurship which are usually taught at this level.

13. **Studying the results in 9 and drawing conclusions, using 12**
    Students work actively in steps 4-9 but the role of mentors is critical for their argumentation, main conclusions and validity of results. The models that are applied should be relevant t their grade/age and experience. Main aspect of evaluation and success factor is their understanding for the real-life applications and practical use of the results. This is supported by the videos that they should prepare which proves how they perceive the knowledge gained in class.

14. **Applications in Everyday Life - Suggestions for Developing 9 (Entrepreneurship - SIL Days)**
    The research of case studies of famous people can lead to direct application to other fields and businesses. Their projects can be leveraged and developed further in 11th grade with work with business owners, managers and employees who provide their cases to be solved. The role of T1 here is important. The challenge can be related to innovation of businesses – established or start-ups who need fresh look and ideas.

Review (by teachers)

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

The main findings of students are structured in sub-areas and specific topics that they should identify to find the main problem and then provide recommendations. Teachers act as mentors and monitor if and how the case study is analysed.

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

As described in step 14 the projects can be extended to draw conclusions and compare results with real companies and/or other organisations who agree to work with students on defined challenge to test new approaches and ideas, e.g. how the approaches of successful people/companies would affect their business.

18. Presentation of Conclusions - Communication Tactics

The final presentations should consist of two main parts:

- Presentation with key findings, recommendations and conclusions with graphs, images, etc.
- Video telling a compelling story that complements the presentation and the
- Preparation of tables, spreadsheets, graphs, etc. to represent analysis of answers from the online questionnaires.
- Use of social media and e-learning platforms for communication with the teachers and in the teams.

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

Brief Description/Outline of Organizational Arrangements / Responsibilities for Action

STAGE	**Activities/Steps** Teacher 1(T1) Cooperation with T2-T5 and student guidance	**Activities /Steps** **By Students** Age Group: 10th grade (16 years old)	**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

LEARNING & CREATIVITY PLAN (L&C PLAN): A "SMART" VILLAGE ON THE MOUNTAIN SLOPE

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☐	☒	☐	☒	☒

1. Overview

Title	**A "smart" village on the mountain slope!**
Driving Question or Topic	*Utilizing the dam of the area for the production of electricity and the supply of a settlement with electricity, throughout the year. How feasible is this project?*
Ages, Grades, …	*16-18* *K-10*
Duration, Timeline, Activities	*16* *4*45 min + 6*90 min* *7 activities*
Curriculum Alignment	*Types of mechanical energy. Gravitational dynamic energy. Power. Electric energy. Pump and electric generator operation. Dimensions-volume / capacity of 3D shapes. Inductive reasoning / generalization.*
Contributors, Partners	
Abstract - Synopsis	*The students study the possibility of utilizing the dam located in the area where a settlement of 800 inhabitants is built, to cover the needs of the settlement in electricity. They calculate the amount of electricity consumed by the inhabitants of the settlement, to determine the amount of water from the dam that will be used. Then they build a model for raising the amount of water in a tank located at a certain height with the help of photovoltaics. Students explore the dimensions that the tank should have, for a specific required amount of water, given the limitation regarding the perimeter of the base of the tank to be constructed. They cost the project for supplying the settlement with electricity and calculate the time it will take to recoup the costs of such a solution.*
References, Acknowledgements	

2. STEAME Framework*

Teachers' Cooperation	**• Teacher 1 (T1) - Teacher of Design and Technology** Teaching the basic principles of operation of photovoltaics, pump and electric generator. Construction of a model with lifting water from one container to another located higher with the use of photovoltaics and utilization of water for electricity production. Coordination of groups. Technology Laboratory. **• Teacher 2 (T2) - Teacher of Physics** Teaching the concepts of dynamic energy and power. Experiment of calculating the power and the electrical energy consumed in an electrical circuit and the useful power. Study of the model constructed in the Technology course Physics Laboratory. **• Teacher 3 (T3) - Teacher of Mathematics** Investigation of the dimensions of a rectangular parallelepiped and a cylinder in relation to the volume and area of their base. The aim is to discover the dimensions of the solids that give maximum base area for a given fixed base perimeter and are selected at a specific height to achieve the given solid volume. **• Teacher 4 (T4) – Teacher of Economics (or Mathematics, if there is no Teacher of Economics in school)** Economic research for the electrification of a city at night with the use of photovoltaics to raise the amount of water during the day to a level and utilization of its dynamic energy for electricity production at night.
STEAME in Life (SiL) Organization	Efforts to harness solar energy and other renewable energy sources for detoxification from fossil fuels are a constant concern for society.

Action Plan Formulation	**STAGE I:** Preparation by T1 and T2 [STEPS 1-3], and **STAGE II:** Formulation of an Action Plan [Preparation of STEPS 1-2] by the teachers. **STAGE II:** Formulation of an Action Plan [Implementation of STEPS 3-11]… The support, feedback and evaluation by the teachers is present during the implementation of the activities and not only the final result. **STAGE II:** Formulation of an Action Plan [Implementation of STEPS 3-11]… Refers to the realization by the students of the activities of the Learning Plan. **STAGE II:** Formulation of results by students and guidance by teachers (STEPS 12-14). Intermediate control by teachers and feedback to students (STEP 15) **STAGE II:** Repeat steps 5 - 11, if necessary, draw final conclusions and communicate them (STEPS 16 - 18).
3. Objectives and Methodologies	
Learning Goals and Objectives	1. Design and perform experimental activities to calculate the power delivered to an electrical circuit from an electrical source. 2. To design and construct models for the simulation of a phenomenon or a process. 3. Collect and record data using various methods, such as observation, measurement / recording 4. To investigate relationships between the dimensions of prisms and their volume or the area of their base. 5. Conduct market research, process financial data and draw conclusions about the viability of a project.
Learning Outcomes and expected Results	1. Experimental data on the power consumed in a circuit. 2. Construction - model for storage of solar energy by lifting water. 3. Economic study for the viability of such a project
Prior Knowledge and Prerequisites	Basic knowledge of electricity (Ohm's law, construction of an electrical circuit, use of ammeter and voltmeter, the concept of power and the calculation of energy consumed in an electrical circuit). Identification of prism characteristics, application of flat shape finding types and prism volume. Construction of a graph with ordered pairs.
Motivation, Methodology, Strategies, Scaffolds	Teachers motivates their students by presenting some real data about the electrical energy consumption in their town, how much this fact costs and what ecological problems are caused to produce this energy. ry approach, individual work and group work.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	The teaching of the basic concepts of Physics for electrical circuits, electrical power and mechanical energy items and the experimental activities for measuring the electrical power consumed in a circuit will be implemented by T1 in the Physics laboratory. The teaching of the operation of photovoltaics, pump and electric generator will be done by T1 in the Technology laboratory. The support of the students for the investigation that they will do for the cost of the project will be done by the T3 in collaboration with the T1 and T2.
Resources, Tools, Material, Attachments, Equipment	• Materials for the construction of an electrical circuit and measurements from the Physics laboratory. • Materials for the construction of the model are supplied by T1 from the Technology laboratory. • The mathematical investigation will take place in the Mathematics´ course. • Data on the consumption of electricity by the population of a city can be obtained from the Electricity Company of the area.
Safety and Health	Safety measures observed in Physics and Design and Technology laboratories
5. Implementation	
Instructional Activities, Procedures, Reflections	**Activity 1: Teamwork** The topographic plan of a small village located near a dam (or river or natural or artificial lake) on a hillside is shown and students are asked to think and record ways to turn this settlement into a "smart village". They can search for relevant information on the internet to determine what "smart village" (or "smart city") means. The ideas they will propose should be based on and utilize the location of

the village and the surrounding area. The group proposals are presented and discussed.

Activity 2: Working with the whole class

The following key question of the project is presented, which will be addressed by the students: "How will the dam of the area and the solar energy be used to produce electricity for the needs of the settlement?". Ways of collecting solar energy in the settlement, ways of converting solar energy into electricity throughout the year and how the water of the dam can be utilized in this project are discussed.

The stages of the work and the individual elements and steps included in each stage are mentioned and recorded. It is reported that the water from the tank returns to the lake through an electric generator, producing electricity, which is used to supply electricity to the settlement.

Activity 3: Electricity consumption

The students estimate the electricity consumed by a house and then calculate based on this estimate, the total amount of electricity consumed by the settlement of 800 inhabitants. If the students are not familiar with the concepts of power and energy consumed in a circuit, then they perform the following experimental activity:

In the Physics laboratory, the teams build an electrical circuit with an electrical source, a resistor (lamp), an ammeter switch and a voltmeter. They make the necessary measurements and calculate the power supplied to the circuit by the electrical source and the electricity consumed in the circuit at a given time.

Activity 4: Construction of a model for raising the amount of water (group work)

The students design a model for lifting water from the dam to a tank located at a certain height. Photovoltaics are used to raise the water during the day with sunshine. The number of photovoltaics that will be required to complete this activity is obtained through research done by students on the internet with reference to their power.

The teams investigate the energy efficiency of their construction, measuring the electrical power produced by their model and comparing it in proportion to the power provided by the photovoltaic they have chosen from the market as the most suitable.

Activity 5: Tank dimensions

Given that the tank will be placed at a height of 200 m above the dam, students calculate the amount of water that should be stored in it, based on the dynamic energy that the water will have at this height and efficiency of generators.

Next, the students explore the dimensions that a tank with a capacity of 4500m3 of water should have, since the total volume of water required is 45000 m3 and 10 identical tanks will be constructed. The shape of the tank should be a rectangular parallelepiped with a base perimeter of 120 m and at the same time it should cover the maximum ground surface.

Fill in a table with the dimensions of the tank (Worksheet X) and make a graph of the area of the tank base and the length of its base. They investigate when the base of the tank has a maximum area for the given perimeter of 120m and generalize. They discuss their conclusions in plenary. The investigation can be expanded by inviting students to make corresponding calculations if the shape of the tank is cylindrical.

Activity 6: Economic study of the electricity supply of the settlement based on the model that was constructed

Each group of students develops an action plan for the financial study of the electricity supply of the settlement based on the data they have studied and collected in the previous activities. They investigate the total cost of the project, the time required to amortize the costs and present concerns and arguments as to whether this project is sustainable.

	Activity 7: Presentation of works Each group presents its measurements, constructions and financial study. The work of all the groups is discussed and in the plenary the final rubric of the evaluation of the whole action is agreed.
Assessment - Evaluation	The feedback and evaluation is continuous and continuous throughout the actions until the presentation of the results. In addition, students evaluate their own work based on the discussion during the presentation phase of their work.
Presentation - Reporting - Sharing	Presentation in the plenary of the department and in the school magazine. Exhibition of models made in a suitable place in the school.
Extensions - Other Information	Depending on the results of the research, the research can be modified to explore the possibility of applying the idea on a smaller scale to the needs of an area of the city. The role of the geomorphology of the area and how much it supports such a solution for electrification can also be explored.

STEAME 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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

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

LEARNING & CREATIVITY PLAN (L&C PLAN):
How to balance Function in Liquid Packaging

S	*T*	*Eng*	*A*	*M*	*Ent*
☒	☐	☒	☒	☒	☒

1. Overview

Title	How to balance function and presentation in Liquid Packaging?
Driving Question or Topic	Why designing a product is complicated? Does it affect the product's sales? What is important when designing a packaging for liquid products?
Ages, Grades, …	Ages: 15-17 10^{th}- 12^{th} grade
Duration, Timeline, Activities	6 LEARNING HOURS 6*45 MINUTES 8 ACTIVITIES
Curriculum Alignment	WHAT IS PRODUCT DESIGN? WHAT ARE THE CONSTRAINTS WHEN WE DESIGN A LIQUID PACKAGE?
Contributors, Partners	
Abstract - Synopsis	During this 6-hour L&C plan pupils should understand the concept of designing liquid packaging. They will learn about liquids and understand the importance of packaging in the food supply chain. All teachers, cooperating in this L&C plan will teach how to balance function & design in liquid packaging. Students have to understand that successful packaging is a balance of both functionality and appealing design. At the end of this plan the peer-assessment will be implemented to assess the design part whereas the functionality of packaging will be assessed by the teacher of physics.
References, Acknowledgements	● https://retailminded.com/how-product-packaging-affects-sales/#.X2CX15MzbBI ● https://www.packagingstrategies.com/articles/94548-how-to-balance-function-and-design-in-liquid-packaging ● https://www.livescience.com/46972-liquids.html

2. STEAME Framework

Teachers' Cooperation	Teacher 1: Economics/ Entrepreneurship (T1) T1 is the first teacher that introduces to students the concept of product design. The teacher explains the importance and the role of the product design both from the scope of functionality and sustainability and the appearance that plays an important role in the sales. Teacher 2: Physics (T2) T2 teaches the properties of liquids. Students should understand that liquids differ from solids and these differences play significant role in the liquid packaging. T2 is the one that evaluates students' efforts in terms of functionality. Teacher 3: Arts (T3) T3 shows students packages and helps them to design their own package. When students design either on paper or with the help of a certain software T3 helps them in this process. Teacher of Arts is responsible for strengthening students' creativity. Teacher 4: Informatics (T4) T4 helps students in the last activity of this L&C plan. Each team conducts a poll and with the help of basic Spreadsheet tools (e.g. Microsoft Excel) conclude to the most favorite liquid packaging among their peers.

SiL Organization	If there is a possibility an expert in designing packaging for liquid products should be invited. In this way, students will understand better the concept and comprehend the reasons why a product should be functional on one hand and 'good-looking' on the other so as to increase its sales entrepreneurial-wise.
Action Plan Formulation	**STAGE I**: Preparation by three teachers [STEPS 1-4], and **STAGE II**: Action Plan Formulation [Preparation STEPS 1-3]… Refers to the creation of this Learning Plan, by the three teachers in collaboration. **STAGE II**: Action Plan Formulation [Development STEPS 4-14, 16-17]… Refers to the realization by the students of the three activities of the Learning Plan. **STAGE II**: Action Plan Formulation [STEPS 15, 18]… Refers to the evaluation by the teachers [15], and the presentation by the students of their results [18].
3. Objectives and Methodologies	
Learning Goals and Objectives	By the end of the L&C Plan, students should be able to: • describe the properties of liquids, • apply their knowledge on liquids in the process of designing liquid packaging • determine the work of a product designer and its effectiveness when it comes to the sales and the lifespan of a product • conduct mini polls and create short reports on their findings.
Learning Outcomes and expected Results	Students (in teams) will: • decide on the liquid product they wish to design • design their own liquid packaging (considering both the functionality of the product and the appearance) • conduct mini quantitative research (in the form of mini polls) and analyze the results • write short reports on the process they followed during their project and the results
Prior Knowledge and Prerequisites	Basic knowledge of spreadsheets and the ability to conduct polls. Global market perception (impact of packages on consumer's behavior, how the appearance of a product affects the decision of a consumer). Basic knowledge of designing.
Motivation, Methodology, Strategies, Scaffolds	The main methodologies and techniques of the course are based on inquiry-based learning. As a matter of fact, students are encouraged to explore the material, prioritize data, ask questions and share ideas. Inquiry-based learning uses different approaches to learning, including small-group discussion and guided learning. Students are involved in designing and conducting their own project research after having some queries and case studies. Specifically, students learn by making their own liquid packaging, instead of memorizing facts and material. This allows them to build knowledge through exploration, experience and discussion. In addition, students get the chance to explore liquids more deeply and the effect of packaging in the marketplace. Students have the opportunity to investigate a problem and find possible solutions, make comments and questions to test ideas, think creatively and use their intuition. As they explore this Learning Plan, students build critical thinking and communication skills. Last but not least, team working, and brainstorming can get the student on the path to success.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	Laptops in the classroom will be necessary for students, in order to design their products and with the help of their teacher of informatics they will use a Spreadsheet App in order to find which design was voted most by their peers. According to lesson activities, students should mainly work in groups of 4-5. Also, the teacher of physics will help them to learn more about liquids, one of the four fundamental states of matter. Moreover, the art teacher should provide students with sheets (preferably A3) so that they can design their packaging. In case students are familiar with design programs that will help them in this activity they can use it. During this procedure, if one group wants to ask a question, then a representative of the other group could help.

Resources, Tools, Material, Attachments, Equipment	● Kahoot created by the teacher: https://kahoot.it/ Kahoot will be mainly used by the Teacher of Physics. The teacher will focus on mechanical properties (volume, pressure, flow) and thermodynamics (phase transitions, liquids in space, solutions) of liquids. ● POLL App: poll will be created by students. The application should have the option to upload a photo so as for pupils to update their design and ask their peers for votes. ● Learn how to sketch like a product designer shown by the Art Teacher (video) https://www.youtube.com/watch?v=iVy0qGqmKFU ● Spreadsheet App or another statistics software Once the product design is ready, students will ask their peers (they can ask the opinion from their peers in the whole school not just a class) which design they like the most. Then, with the help of their teacher and with the appropriate software they will come to their results. ● Design Program This is not obligatory. Students can draw with pencil and paper their product instead.
Safety and Health	
5. Implementation	
Instructional Activities, Procedures, Reflections	The plan can be completed in six learning hours. In the beginning (a learning hour of 45 minutes to complete this task) the teacher (economist) explain to students what a product design is, who is responsible for creating the product, what he/she has to have in mind so as to complete this task. **1. Brainstorming (10 minutes)** This activity help students to understand how much existing knowledge they have – perhaps without even realizing they have it. In 4 or 5 different workstations around the room; each station should have an A3 piece of paper with an opinion on what product design is, what we should take care of when designing a liquid packaging and whether they have bought a liquid product just because they like how the package looked. **2. What is product design? How it can affect the sales of a product (35 minutes)** The economist teacher explains what product design is and discusses with her/his student whether it is important or not to have a good quality and good-looking packaging. They also watch some of the inspirational videos so as to understand better the importance of product designing. In the second hour students are asked to brainstorm, express their opinion and then share it with their class and decide on which product they will design. All teams should design the same product such as a bottle of water in order to be easily compared between them. They can choose whichever liquid they wish but they will have to know and the specifications of each product. For example, there are differences between designing a bottle of water that one of the main characteristics of the package should be to ensure the quality of the product that the consumer receives, and it is completely different to design a detergent package. **3. 'Exploring Liquids' Lesson (45 minutes)** During this learning hour, the teacher of physics presents a comprehensive unit on fluids. Students will experiment with a variety of household liquids to determine their flow rate and compare their viscosities. Also, asks from pupils to explain in qualitative terms the relationship between pressure, volume and temperature. **5. Share & exchange ideas and take decisions on what they will create (45 minutes)** Students in teams of 4-5 will discuss what they have learnt. They share their ideas. Each team has a representative that can pose his/her team's questions to the teacher or to his/her classmates. At the end of this session students have to, at least, have a first opinion on the packaging they will design.

6. The creation of packaging per group (90 minutes)
Every team, along with their Art teacher they will use a design program in order to design their packaging. While they are designing the package, they have to be aware of the following:

- *Aesthetics*: is the most obvious part of the design process and it is the first that consumers will notice. Part of this element is the packaging.
- *Ergonomics*: ensure that the product is as comfortable and as intuitive to use as possible.
- *Materials*: it is less important at this stage. However, students should consider that some materials are not easy to use. A separate learning hour (not considered in this lesson plan) may explain the differences between different basic materials.
- *Sustainability*: it is important to ensure that the chosen materials and components are easy to find and in good supply.
- *Protection*: ensure that the product has the necessary protection from the environment and its usage to maintain its prolonged use.
- Especially when designing liquid packaging students should consider the following:
- *Viscosity of the liquid: If equipment is used for the wrong viscosity level, it could significantly hinder productivity, and breakdowns are more likely to occur.*
- Specific product challenges: transportation, packing dangerous liquids, prevent leakages, hygiene and safety regulations, temperature requirements.

Once the design is ready students are asked to show their results to their peers. At the end of this learning hour students are asked to write a report on their design, the results from their research as well as the procedures they followed during this project.

7. Ask their peers to decide which design they prefer (during breaks)
Students will present their designs to their peers and then they will choose their favorite. That is a task that can happen during school breaks. In this certain stage students should have their personal tablet so as to present their designs. Maybe they can organize short presentations for their peers to understand their thinking behind each design so as to have a holistic view of the product.

8. Final results on which product design got the most votes. Write a small report (45 minutes)
In this certain stage, both the Teacher of Informatics and a Mathematician can co-teach. Using certain and basic knowledge of statistics will conduct a quantitative research and reach to a result. Why the majority of students like a certain design the most? (this question might be the basic answer on which students will be based on to write their short report).

Assessment - Evaluation

- Peer Assessment via advertising (activity 7), where not only their classmates but also peers from the school decide on the best design.
- Teacher Assessment who evaluates the effectiveness of the package and if it is in alliance with the rules set for liquids (formative assessment).

Presentation - Reporting - Sharing

A presentation by each group takes place in the final activity, analyzing the steps from the choice until the development of their own advertisement. Students should present all the variables that take into consideration in order to complete their design and the poll.

Extensions - Other Information

1. Students can expand this plan by exploring certain materials and their properties. Pupils may be given the chance to decide by themselves whether they wish to have a plastic or a glass bottle. They can observe and list the pros and the cons of each material in terms of cost, eco-friendly etc. Also, they can look for other, less known, materials.
2. At the end of this L&C plan students can present their results to the whole school. Also, depending on their experience they can design a 3d version of their package.

LEARNING & CREATIVITY PLAN (L&C PLAN): Floppy Heart Valves

S	*T*	*En g*	*A*	*M*	*En t*
☒	☒	☒	☐	☐	☐

1. Overview

Title	Floppy Heart Valves
Driving Question or Topic	What Do I Need to Know about Heart Valves? Does My Model Valve Stack up to the Real Thing?
Ages, Grades, …	Ages: 9-12 Grade: 11
Duration, Timeline, Activities	5h and 45 min duration Seven 50minutes class periods
Curriculum Alignment	Biology, Life Science, Science and Technology Contributors, Partners 2 lessons and 2 activities
Abstract - Synopsis	Students are presented with an engineering challenge that asks them to develop a material and model that can be used to test the properties of aortic valves without using real specimens. Developing material that is similar to human heart valves makes testing easier for biomedical engineers because they can test new devices or ideas on the model valve instead of real heart valves, which can be difficult to obtain for research. To meet the challenge, students are presented with a variety of background information, are asked to research the topic to learn more specific information pertaining to the challenge, and design and build a (prototype) product. After students test their products and make modifications as needed, they convey background and product information in the form of portfolios and presentations to the potential buyer.
References, Acknowledgements	Teach Engineering https://www.teachengineering.org/curricularunits/view/van_floppy_unitdoc The contents of this digital library curriculum were developed under National Science Foundation RET grant nos. 0338092 and 0742871

2. STEAME Framework

Teachers' Cooperation	1st Teacher: Biologist 2nd Teacher: Healthcare Professional
STEAME in Life (SiL)	Student groups are challenged to develop a material that mimics the behavior and mechanical properties of aortic valves. To do this, students study the problem, learn as much about heart valves as they can, and apply their knowledge towards the design, building and testing of a material and model that meets the buyer's needs.
Action Plan Formulation	**Action Plan Overview:** STAGE I: Generation of ideas and gathering of multiple perspective information by students. STAGE II: Lesson 1 and associated activity Plan formulation STAGE III: Lesson 2 and associated activity Plan formulation

3. Objectives and Methodologies

Learning Goals and Objectives	By the end of the L&C Plan, students should be able to be familiar with all the steps that are needed for developing a material that mimics the behavior and mechanical properties of aortic valves. More specifically the students should be able to: (a) Identify major structures of the human heart on diagrams and organic specimens. (b) Describe the flow of blood through the human heart. (c) Describe the structure and function of heart valves. (4) Describe the steps and the process needed for developing a material
Learning Outcomes and expected Results	Once the plan is completed, students will be able to know the basics about heart valves forces that act on heart valve tissue, as well as elasticity, stress, strain, Young's modulus and how to calculate Young's modulus for materials. design and test their prototype heart valve models.
Prior Knowledge and Prerequisites	Students should be familiar with the components of the cardiovascular system and the basic structure of the heart, including the names and positions of the four chambers.
Motivation, Methodology, Strategies, Scaffolds	The main methodologies are inquiry-based learning and problem-based learning. Engineers investigate ways to improve problems that humans face by developing solutions, and then researching, building, testing and redesigning those solutions to improve upon the initial design. Often what is needed does not exist, so it is up to engineers to develop novel materials, structures or procedures to solve the problems. Bioengineers perform all these tasks, but with a focus on biological materials, processes or chemicals. In this case, student groups are challenged to develop a material that mimics the behavior and mechanical properties of aortic valves. To do this, students study the problem, learn as much about heart valves as they can, and apply their knowledge towards the design, building and testing of a material and model that meets the buyer's needs.

4. Preparation and means

Preparation, Space Setting, Troubleshooting Tips	Model Heart Valves - Student teams follow the engineering design process to design, build, test and redesign a functioning model heart valve. Each group also creates a brochure explaining how its heart valve functions. Teams present their designs to the teacher and class, showing a demonstration of their model heart valve, explaining their brochure, and describing how their design could be a solution to this unit's Grand Challenge question.
Resources, Tools, Material, Attachments, Equipment	• Lesson 1: What Do I Need to Know about Heart Valves? https://www.teachengineering.org/lessons/view/van_floppy_lesson01 • Lesson 2: Elasticity & Young's Modulus for Tissue Analysis(https://www.teachengineering.org/lessons/view/van_floppy_lesson02) • Lesson: Blood Pressure Basics https://www.teachengineering.org/lessons/view/van_heartvalves_lesson02 • Lesson: Heart to Heart https://www.teachengineering.org/lessons/view/van_heartvalves_lesson01
Safety and Health	

5. Implementation

Instructional Activities, Procedures, Reflections	Activity 1. Introduce students to the challenge problem This "legacy cycle" unit is structured with a contextually based Grand Challenge followed by a sequence of instruction in which students first offer initial predictions (Generate Ideas) and then gather information from multiple sources (Multiple Perspectives). Activity 2. “Research and Revise” phase during which students integrate and extend their knowledge. Activity 3. The cycle concludes with formative (Test Your Mettle) and summative (Go Public) assessments that lead students towards answering the Challenge question. See below for the progression of the legacy cycle through the unit.

Research and ideas behind this way of learning may be found in How People Learn: Brain, Mind, Experience and School (Bransford, Brown & Cocking, National Academy Press, 2000); see the entire text at https://www.nap.edu/read/9853/chapter/1.

The legacy cycle is similar to the engineering design process in that they both involve identifying an existing societal need, applying science and math to develop solutions and using the research conclusions to design a clear, conceived solution to the challenge. Though the engineering design process and the legacy cycle both result in viable solutions, each focuses differently on how the solution is devised and presented. See an overview of the engineering design process in the engineering design handout inthe final activity,or at https://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html#.VDSAGvldUnE.

Examples of the activities adapted in 2 lessons:
Lesson 1. In What Do I Need to Know about Heart Valves?
Activity 1. Students are introduced to the challenge question and exposed to some basic information relevant to the topic of heart valve tissue.
Activity 2. The previous activity supplies the Challenge, Generate Ideas, and Multiple Perspective portions of the legacy cycle.
Activity 3. Students wrap up the lesson by researching heart valve mechanics and valve tissue anatomy and details.

These activities represent the Research and Revise portion of the legacy cycle. In the Mighty Heart associated activity, student groups dissect sheep hearts to see and feel its structure, including valves, and learn more in-depth information about valves.

Lesson 2. In Elasticity & Young's Modulus for Tissue Analysis
Activity 1. Students learn about the forces that act on heart valve tissue, as well as elasticity, stress, strain, Young's modulus and how to calculate Young's modulus for materials. They complete some practice problems to solidify their understanding.
Activity 2. In the Does My Model Valve Stack up to the Real Thing? associated activity, students research materials suitable for their model valves. They test possible materials to evaluate them for similarities to real heart valves.
Activity 3. Students design and test their prototype heart valve models. Students refine their models after testing and before presenting the information to the teacher and class as an information packet. The work accomplished in this activity represents the Test Your Mettle and the Go Public portions of the legacy cycle.

Assessment - Evaluation

Assessment
Pre-Lesson Assessment

Engineering and the Body Class Discussion: Ask students if they believe engineering has anything to do with the health of the human body. Begin a class discussion to assess how familiar students are with engineering's involvement in the medical industry by asking the following questions:

Do you think engineers play any role in our health? (Answer: Yes)
What is an example of an engineer whose work might affect our health? (Possible answers: Biomedical engineers work with doctors and surgeons to design medical technologies, tools, equipment and procedures, chemical engineers design medicines, and civil and environmental engineers create infrastructure that provides drinking water treatment, waste water treatment and air quality, which all have a direct influence on public health.)
What type of engineer might work hand in hand with a doctor to help a patient with heart disease? (Answer: A biomedical engineer designs technologies that doctors can use, such as stents to open arteries clogged by plaque build-up, artificial heart valves to replace deteriorated or injured heart valves, and artificial hearts that pump blood through the body during surgeries and even after a person's biological heart fails.) Post-Introduction Assessment

	Brainstorming: Assess students' prior knowledge based on their brainstorming session feedback with the Challenge Question Brainstorm Worksheet. Gauge what they already know about the heart from their responses. Lesson Summary Assessment Heart Disease and Defects Research: Have students conduct Internet research to learn more about heart diseases as well as various defects. Require students to research at least 10 different types of heart diseases, including at least one disease of the heart valves, take notes, and write brief summaries (two paragraphs) about each disease to turn in for grading. Have them incorporate the vocabulary words—such as left and right atria, left and right ventricle, tricuspid valve, mitral valve, interventricular septum, aorta, aortic valve, superior and inferior vena cava, pulmonary arteries and pulmonary veins—in the summaries.
Presentation - Reporting – Sharing Extensions - Other Information	Students present their work to the teacher and class as an information packet.

STAGE I: Generation of ideas and gathering of multiple perspective information by students (STEPS 1-3)

1. First stage is structured with a contextually based *Grand Challenge* followed by a sequence of instruction in which students first offer initial predictions (Generate Ideas) and then gather information from multiple sources (Multiple Perspectives).
2. This is followed by a *Research and Revise* phase as students integrate and extend their knowledge through a variety of learning activities.
3. The stage concludes with formative (Test Your Mettle) and summative (Go Public) assessments that lead students towards answering the Challenge question. Research and ideas regarding this way of learning may be found in *How People Learn: Brain, Mind, Experience and School (Bransford, Brown & Cocking, National Academy Press, 2000);* see the entire text at https://www.nap.edu/read/9853/chapter/1.

   This stage is similar to the engineering design process in that they both involve identifying an existing societal need, applying science and math to develop solutions and using the research conclusions to design a clear, conceived solution to the challenge. Though the engineering design process and the legacy cycle both result in viable solutions, each focuses differently on how the solution is devised and presented. See an overview of the engineering design process in the engineering design handout in the final activity, or at https://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html#.VDSAGvldUnE.

STAGE II: Lesson 1 and associated activity Plan formulation (2 steps)

1. In **What Do I Need to Know about Heart Valves?** (lesson 1), students are introduced to the challenge question and exposed to some basic information relevant to the topic of heart valve tissue. This supplies the Challenge, Generate Ideas, and Multiple Perspective portions of this stage. Students wrap up the lesson by researching heart valve mechanics and valve tissue anatomy and details. These activities represent the *Research and Revise* portion of this stage.

2. In **The Mighty Heart** associated activity, student groups dissect sheep hearts to see and feel its structure, including valves, and learn more in-depth information about valves.

STAGE III: Lesson 2 and associated activity Plan formulation (2 steps)

1. In **Elasticity & Young's Modulus for Tissue Analysis** (lesson 2), students learn about the forces that act on heart valve tissue, as well as elasticity, stress, strain, Young's modulus and how to calculate Young's modulus for materials.

2. They complete some practice problems to solidify their understanding. In the **Does My Model Valve Stack up to the Real Thing?** associated activity, students research materials suitable for their model valves. They test possible materials to evaluate them for similarities to real heart valves. Then they design and test their prototype heart valve models. Students refine their models after testing and before presenting the information to the teacher and class as an information packet. The work accomplished in this activity represents the Test Your Mettle and the Go Public portions of the legacy cycle.

Learning and Creativity Action Plan Schedule

Plan on the unit taking seven 50-minute class periods, according to the following schedule (Table I). Further resources on Lessons and Activities learning material can be accessed in the following links:
https://www.teachengineering.org/lessons/view/van_floppy_lesson01
https://www.teachengineering.org/lessons/view/van_heartvalves_lesson01
https://www.teachengineering.org/lessons/view/van_floppy_lesson02
https://www.teachengineering.org/lessons/view/van_heartvalves_lesson02

Table I (Action Plan Schedule)

Day	Document	Curricular Document Title	Time required
1-2	Lesson 1	What Do I Need to Know about Heart Valves?	100 minutes (2*50 minutes)
3	Activity 1	The Mighty Heart	45 minutes
4	Lesson 2	Elasticity & Young's Modulus for Tissue Analysis	50 minutes
5-7	Activity 2	Does My Model Valve Stack up to the Real Thing?	150 minutes (3*50 minutes)

LEARNING & CREATIVITY PLAN (L&C PLAN): NETWORK ANALYSIS

S	*T*	*Eng*	*A*	*M*	*Ent*
☐	☒	☐	☒	☒	☒

1. Overview	
Title	Network Analysis
Driving Question or Topic	How to use Graph Theory in order to represent and analyze networking.
Ages, Grades, …	Ages: 12-18 7^{th} -12^{th} grades
Duration, Timeline, Activities	3-4 DIDACTIC HOURS 4 activities
Curriculum Alignment	Discrete Math, Algebra Matrix Operations, Computer applications
Contributors, Partners	
Abstract - Synopsis	Students will learn how to use Graph theory concepts with spanning trees, weighted graphs, shortest paths in order to analyze networks. In real life it means to minimize the expenses of a company by selecting the shortest path and improve efficiency.
References, Acknowledgements	Edexcel AS and A level Further Mathematics- Decision Mathematics 1 - D1 Matrices Pearson IGCSE
2. STEAME Framework	
Teachers' Cooperation	1^{st} Teacher: Mathematics 2^{nd} Teacher: Computers
STEAME in Life (SiL) Organization	A real meeting with the person responsible to carry out the routes of their local post office or local central bus station.
Action Plan Formulation	Stage i: The Mathematics teacher introduces the concept of Graph theory with some useful links for the students to create a better understanding on the topic. Stage ii: The teacher will assign various problems that affect a network analyses such as routes for bus/train transportation. Stage iii: Action plan formulation. Refers to the creation……
3. Objectives and Methodologies	
Learning Goals and Objectives	By the end of the L&C Plans, students should be able to know and complete the following: • Important factors that affect the networking • Data collection and organizing data. • Representation of the data using graphs • Representation of the data using matrices
Learning Outcomes and expected Results	Upon completion of the project, learners will produce a better understanding of the complexity of networking and fosters their curiosity about new methods

	could be introduced, Their communicative skills will be enhanced, as they will be obliged to make decision as partners.
Prior Knowledge and Prerequisites	No background information is needed.
Motivation, Methodology, Strategies, Scaffolds	The main methodologies and techniques of the course are based on inquiry-based learning. In this way, students are encouraged to explore the material, prioritize data, ask questions and share ideas. Inquiry-based learning uses different approaches to learning, including small-group discussion and guided learning. Students are involved in designing and conducting their own scientific research after having some queries and case studies. Specifically, students learn by making their own representation, instead of memorizing facts and material. This allows them to build knowledge through exploration, experience and discussion. In addition, students get the chance to explore various factors and learn from their own first-hand experience. Students have the opportunity to investigate a problem and find possible solutions, make comments and questions to test ideas, think creatively and use their intuition. As they explore this Learning Plan, students build critical thinking and communication skills. The cognitive skills that students develop can be used to improve comprehension in every subject, as well as in day-to-day life. Last but not least, team working and brainstorming can get the student on the path to success.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	The theoretical framework will be taught in the classroom. However, the students will process the various factors of their decision. It is important that the students discuss the many factors involved in this problem, rather than just focusing on a single dimension. Is there a cost savings with eliminating on route of the direction? What are the needs of the customers and the company? What about new customers who may be deciding their directions? How do you decide which routes to eliminate and what alternatives can you offer?
Resources, Tools, Material, Attachments, Equipment	Examples, YouTube links, power point presentation created by the teacher. The tools needed will be access to computers in order to represent their data with the help of the Computer teacher. Mainly for Excel or TI-83 or Geometer's Sketchpad. Resources: Graph theory: 1. https://www.youtube.com/watch?v=C7YrMRdLkqo&list=PLHXZ9OQGMqxersk8fUxiUMSIx0DBqsKZS&index=76 2. https://www.youtube.com/watch?v=gC0RNpD2P1Y&list=PLHXZ9OQGMqxersk8fUxiUMSIx0DBqsKZS&index=77 3. https://www.youtube.com/watch?v=WTNBNSUhSTY&list=PLHXZ9OQGMqxersk8fUxiUMSIx0DBqsKZS&index=78 4. https://www.youtube.com/watch?v=dSK5jTEe-AM&list=PLHXZ9OQGMqxersk8fUxiUMSIx0DBqsKZS&index=79 Matrices: 1. https://www.youtube.com/watch?v=PPOIlLhsT6s

Safety and Health	
5. Implementation	
Instructional Activities, Procedures, Reflections	The plan can be completed in six learning hours, the first two hours will be the understanding of graph theory-spanning trees-degree of a vertex-Eulerian path and Eulerian circuit (power point is included). The two second hours will be two activities related to the understanding how graphs can be useful to represent real life problems given various factors (included on the power point). The last two hours is for students to present their ideas for their task with the help of the ID teacher either on Geometer's Sketchpad or excel. The teacher can use the attached power point, YouTube links attached or the book of the Decision Mathematics 1 chapter 2 to explain the concept of the Graph Theory and shortest route on chapter 3. The second part will be to provide some examples of transportation companies where they need to cover some routes by using the shortest path but also including the needs and perspective of their clients. Last part will be the students to be given their own task where they need to split into groups and represent their own ideas with the help of the second teacher. Each group will develop a recommendation for their work and present this proposal to the class. The presentation may contain, but is not limited to, charts, matrices, adjacency matrices of various path lengths, minimum spanning trees, weighted graphs, and other documentation. Each presentation should be 7 to 10 minutes in length.
Assessment - Evaluation	Exercises are attached, or by using exercises from D1 book. Evaluation will be done by the student's presentation at the end of the lesson.
Presentation - Reporting - Sharing	The sharing processes will be done during the student's presentation.
Extensions - Other Information	

STEAME 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 (STEAME 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 mathematics or other 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 Actions and Cooperation in Creative Projects for school students

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

LEARNING & CREATIVITY PLAN (L&C PLAN):
RESEARCH – SERVICES EVALUATION

S	*T*	*Eng*	*A*	*M*	*Ent*
☐	☒	☐	☐	☒	☒

1. Overview	
Title	**Research – Services Evaluation**
Driving Question or Topic	How do I evaluate the services of a private or public body for continuous improvement?
Ages, Grades, …	AGES:13-18 7^{th} - 12^{th} grade
Duration, Timeline, Activities	22 LEARNING HOURS 11*90 MINUTES 4 ACTIVITIES
Curriculum Alignment	Research Methodology, Statistics, Services Evaluation
Contributors, Partners	
Abstract - Synopsis	Students are involved in a real research process with application in services evaluation. Basic issues and stages of the research process are taught, from the formulation of the problem and the goal to the final presentation of the results and conclusions.
References, Acknowledgements	

2. STEAME Framework*	
Teachers' Cooperation	• 1st Teacher 1 (T1)- Teacher of Economics, Administrative Science Bibliography study, teaching important factors of service quality, presentation of other relevant, similar research. Classroom. • 2nd Teacher (T2) - Teacher of Mathematics, Statistics, Research Methodology Teaching data collection methods, construction of appropriate questionnaires, sampling methods and techniques, methods of checking the validity of the questionnaire, coding of questions and answers, methods of statistical analysis and presentation of results. Classroom. • 3rd Teacher (T3) - Teacher of Mathematics, Statistics, Research Methodology or Computer Science Teaching the construction of electronic questionnaires (eg Google Forms) or data entry (in Excel Spreadsheet or other Database). Teaching statistical analysis methods and graphical presentation of results (using Excel and Analysis Tool Pak or another statistical analysis package eg SPSS). Teaching the creation of a suitable electronic presentation (PPT or INFOGRAPHICS or VIDEO or PPT with voice over) but also the writing an appropriate detailed report that describes all the stages of the research as well as the conclusions. Computer Lab.

STEAME in Life (SiL) Organization	This research activity definitely involves representatives from a body that offers the services under evaluation in most of the teaching and implementation stages.
Action Plan Formulation	**STAGE I**: Preparation by one or more teachers [STEPS 1-3], and **STAGE II**: Action Plan Formulation [Preparation STEPS 1-2]… Refers to the creation of this Learning Plan, by teachers in collaboration . **STAGE II**: Διαμόρφωση Σχεδίου Δράσεως [Development STEPS 3-12]… Refers to the realization by the students of the six activities of the Learning Plan. The support, feedback and evaluation by the teachers is accompanying throughout the implementation of the activities and not only the final result.
3. Objectives and Methodologies	
Learning Goals and Objectives	By the end of the L&C Plan, students should be able to know and complete the following: • Important factors for evaluating Services • Data Collection Methods and Sampling Methods and Techniques • Construction and use of appropriate questionnaires (printed or electronic) • Questionnaire validity and reliability control methods (use of appropriate software) • Methods of statistical analysis and presentation of results (use of appropriate software) • Presentation of results - Writing a detailed research report
Learning Outcomes and expected Results	Upon completion of this research activity, students will be able to follow the stages of a research process, set research goals and objectives, evaluate services or other relative activities, construct questionnaires, collect answers, analyze them and present the results and conclusions of their research. These skills are very important in the 21st century
Prior Knowledge and Prerequisites	Basic knowledge of descriptive statistics and use of spreadsheets (excel).
Motivation, Methodology, Strategies, Scaffolds	The learning process is based on the involvement of students and their teachers in a real process of evaluating the services of a community service provider that would be of interest to students. The result will be a review or improvement of these services, for the benefit of the service provider (s.p.) and for the benefit of the students or citizens who use these services. The importance of the results is in itself a great motivator. On the other hand, the skills acquired throughout the research are also very important for the citizen of the 21st century. These skills are acquired through contacts - consultations with the representatives of the body that offers the services, but also the team work for the construction of questionnaires (printed and electronic), data collection and input, data analysis, presentation of results and drawing conclusions. Throughout this process there is continuous discreet support from teachers and evaluation, feedback for the deliverables at each stage.
4. Preparation and Means	
Preparation, Space Setting, *Troubleshooting Tips*	The theoretical framework will be taught in the classroom. However, the students will process the questionnaires (printed or electronic), the data entry, the statistical analysis and the preparation of the presentation of the results in the computer laboratory (with the support of the teachers).

Resources, Tools, Material, Attachments, Equipment	• Important factors for evaluating Services
	  ○ [EN] 3 Ways to Evaluate Your Services - Foto
	  ○ [EN] How To Measure Quality of Service | Service Quality - Qualtrics
	• Data Collection Methods and Sampling Methods and Techniques
	  ○ [EN] sampling ppt - SlideShare
	  ○ [EN] Sampling techniques - SlideShare
	  ○ [EN] Sampling Design, Questionnaire Design & Data ib - SlideShare
	• Construction and use of appropriate questionnaires (printed or electronic)
	  ○ [EN] questionnaire design in research - SlideShare
	  ○ [EN] Questionnaire and its Types - SlideShare
	  ○ [EN] Top 21 Best Online Survey Software and Questionnaire Tools ...
	  ○ [EN] How to Create a Free Online Survey with Google Docs ...
	• Questionnaire validity and reliability control methods (use of appropriate software)
	  ○ [EN] Reliability test: Compute Cronbach's alpha using SPSS ...
	  ○ [EN] Reliability test: Interpret Cronbach's alpha output in
	  ○ [EN] Calculating Cronbach's Alpha in Microsoft Excel Compared to ...
	• Methods of statistical analysis and presentation of results (use of appropriate software)
	  ○ [EN] How to Use SPSS for Beginners - Online Statistics
	  ○ [EN] SPSS Tutorial (for Beginners): Learn Online in Simple Steps ...
	  ○ [EN] Use the Analysis ToolPak to perform complex data analysis ...
	• Presentation of results - Writing a detailed research report
	  ○ [EN] 5 Ways to Effectively Present Survey Data - Survey Anyplace
	  ○ [EN] Presenting survey results – Report writing - Queensland ...
	  ○ [EN] AN ASSESSMENT OF THE EFFECTIVENESS OF LIBRARY (report)...
	  ○ [EN] An Assessment Of The Effectiveness Of Library Resources (ppt)...

Safety and Health	

5. Implementation	
Instructional Activities, Procedures, Reflections	The plan can be implemented in 22 learning hours. The first 4 are theoretical but also include a meeting or presence of the representative of the body that offers the services that will be evaluated. The rest include a theoretical framework in parallel with practical application, work monitoring, feedback, evaluation. 1. Important factors for evaluating Services (4 learning hours) T1 teaches the important factors of service quality assessment. Meetings (or presence in the classroom) are arranged, with a representative of the body that provides specific service/es that will be evaluated, to make the target and the goal of the research more specific. Bibliography is reviewed to find a possible similar procedure followed by other relevant bodies. 2. Data Collection Methods and Sampling Methods and Techniques (2 learning hours) T2 teaches the methodology of a research process, as well as the various data collection methods and sampling techniques. Students under the guidance of their teacher are asked to choose the appropriate methodology for their own research. Teaching methods of data collection, construction of appropriate questionnaires, methods - sampling techniques, methods of checking the validity of the questionnaire, coding of questions and answers, methods of statistical analysis and presentation of results. 3. Construction and use of appropriate questionnaires (printed or electronic) Questionnaire validity and reliability control methods (use of appropriate software) Methods of statistical analysis and presentation of results (use of appropriate software) (8 learning hours) T2 and T3 in collaboration teach students how to construct appropriate printed or electronic questionnaires. They also teach ways to encode questions and answers, and to enter data or prepare the database for processing. The theoretical framework as well as the use of appropriate software for checking the validity and reliability of the questionnaire, as well as basic methods of statistical analysis of questionnaires are also taught. After completing the theoretical framework, the students are divided into groups. The 1st group deals with the construction of the questionnaire with appropriate questions, the 2nd group is trained in the conversion of the questionnaire in electronic form or in the coding and data input and the 3rd group is trained in data analysis methods using appropriate software. The groups interact with each other both in the initial stages and afterwards. After the questionnaire is constructed in its first version (printed or electronic) it is given for testing to a small group of people. The questionnaire is checked if it is legible, with simple and understandable questions, if bias is avoided from the wording of

	the questions, if the questions measure what we want, etc. Then the appropriate interventions are made for the final form of the questionnaire that will be available for the main survey. From the first, small-scale sharing of the questionnaire, some initial conclusions or some points may emerge that may need more detailed investigation and may need to be included in the final form of the questionnaire. It may be that at some points clarifying open-ended questions need to be added (e.g., indicate what additional service you would like this service body to offer.) At this stage, all three groups of students we mentioned work together. The final questionnaire is then shared to the sample selected for the main survey. 4. Presentation of results - Writing a detailed research report (8 learning hours) Until the questionnaires and the data collection is completed, T3 teaches students methods for effectively presenting the results and writing a research report. When the answers of the questionnaire are collected (all students participate in this process), the first preliminary analysis of the answers is done with simple descriptive statistics. In the first presentation of the results, we have preliminary conclusions and further research issues are discussed and formulated for a more detailed analysis of the questions, in topics that may be of interest, e.g. •Checking the differentiation of the answers according to various demographic data (e.g., Age, Gender, Area, Educational Level, etc.) • Correlations or groupings of the questions • Reliability Test Detailed Statistical Analysis is performed, and appropriate graphics are used for better presentation of the conclusions. The presentation of the results as well as the writing the research report is being prepared. At this point students can work again in groups both to investigate with statistical methods the various questions, but also to prepare the individual stages of the presentation or research report. Alternatively, students can work in groups and each group can prepare different presentations and reports. T1, T2 and T3 provide ongoing support, feedback, and evaluation.
Assessment - Evaluation	The feedback and evaluation is continuous, from the point of construction of the appropriate questionnaire and throughout the process of conducting the research, the analysis and the presentation of the results.
Presentation - Reporting - Sharing	The presentation of the results will be done in front of the representatives of the body that provides the services, but possibly also in front of all the interested students of the school. Both the presentation and the research report can be published on the school website or the websites of the community or the service provider.
Extensions - Other Information	The results will certainly be the trigger for the specific body that offers the services to take actions to improve and modernize the processes and services it provides. Interested students can continue to contribute in this direction and after the end of the research.

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

Research – Services Evaluation

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

Teaching the following important topics:

- Important factors for evaluating Services
- Data Collection Methods and Sampling Methods and Techniques
- Construction and use of appropriate questionnaires (printed or electronic)
- Questionnaire validity and reliability control methods (use of appropriate software)
- Methods of statistical analysis and presentation of results (use of appropriate software)
- Presentation of results - Writing a detailed research report

2. Target Age Group of Students - Associating with the Official Curriculum - Setting Goals and Objectives

It can be taught in all classes from grade 7 to grade 12. Depending on the age of the students and the time available, the level of statistical analysis that will be done may increase.

3. Organization of the tasks of the parties involved - Designation of Coordinator - Workplaces etc.

- 1st Teacher 1 (T1)- Teacher of Economics, Administrative Science

  Bibliography study, teaching important factors of service quality, presentation of other relevant, similar research.

  Classroom.

- 2nd Teacher (T2) - Teacher of Mathematics, Statistics, Research Methodology

  Teaching data collection methods, construction of appropriate questionnaires, sampling methods and techniques, methods of checking the validity of the questionnaire, coding of questions and answers, methods of statistical analysis and presentation of results.

  Classroom.

- 3rd Teacher (T3) - Teacher of Mathematics, Statistics, Research Methodology or Computer Science

  Teaching the construction of electronic questionnaires (e.g., Google Forms) or data entry (in Excel Spreadsheet or another Database).

  Teaching statistical analysis methods and graphical presentation of results (using Excel and Analysis Tool Pak or another statistical analysis package e.g., SPSS).

  Teaching the creation of a suitable electronic presentation (PPT or INFOGRAPHICS or VIDEO or PPT with voice over) but also the writing an appropriate detailed report that describes all the stages of the research as well as the conclusions.

Computer Lab.

STAGE II: Action Plan Formulation

1. Relation to the Real World – Reflection
    a. All Public and Private Sector Bodies, offering Services must be evaluated at regular intervals so that they can redefine their goals and improve their processes, always focusing on providing the best services to their clients.
    b. The evaluation process is considered extremely vital to maintain the quality of the services, but also for maintaining high standards in the modern and rapidly changing needs of the society in the 21st century.

© Can Stock Photo

2. Formulation of a problem (possibly in stages or phases) resulting from the above
Both individually and as social groups we need daily service in various services necessary for our better life in a modern city.
The student / teacher team can contact institutions that offer such services to the community or municipality or any other private organization that would like to work with them to evaluate the services they offer.
The aim is always to identify the degree of satisfaction of those served with various quality criteria, as well as criteria of service necessity and the expectations of "customers", always aiming at the best possible service and optimization of processes and services offered.

3. Background Creation - Search / Gather Information
Students are taught methodology in the processes of evaluation and improvement of services. Meetings are arranged with a specific service/es provider that will be evaluated; the literature is reviewed to find a possible similar process by other relevant bodies.

4. Simplify the issue - Configure the problem with a limited number of requirements
The students in collaboration with the teachers are to detect the basic services in which to concentrate to evaluate as well as the number of people the survey focuses on for the evaluation of these services.

5. Case Making - Designing - identifying materials for building / development / creation
After completing the theoretical framework, the students are divided into groups.
The 1st group deals with the construction of the questionnaire with appropriate questions, the 2nd group is trained in the conversion of the questionnaire in electronic form or in the coding and data input and the 3rd group is trained in data analysis methods using appropriate software. The groups interact with each other both in the initial stages and afterwards.

6. Observation-Experimentation - Initial Conclusions
After the questionnaire is constructed in its first version (printed or electronic) it is given for testing to a small group of people.

The questionnaire is checked if it is legible, with simple and understandable questions, if bias is avoided from the wording of the questions, if the questions measure what we want, etc. Then the appropriate interventions are made for the final form of the questionnaire that will be available for the main survey.
From the first, small-scale sharing of the questionnaire, some initial conclusions or some points may emerge that may need more detailed investigation and may need to be included in the final form of the questionnaire.
It may be that at some points clarifying open-ended questions need to be added (e.g., indicate what additional service you would like this service body to offer.)
At this stage, all three groups of students we mentioned work together. The final questionnaire is then shared to the sample selected for the main survey.

7. Gathering of results / information based on points 5, 6
   First group presentation by students
   When the answers of the questionnaire are collected (all students participate in this process), the first preliminary analysis of the answers is done with simple descriptive statistics. In the first presentation of the results, we have preliminary conclusions and further research issues are discussed and formulated for a more detailed analysis of the questions, in topics that may be of interest, e.g.
   •Checking the differentiation of the answers according to various demographic data (eg Age, Gender, Area, Educational Level, etc.)
   • Correlations or groupings of the questions
   • Reliability Test

8. Configure mathematics or other STEAME models to describe / represent / illustrate the results
   Detailed Statistical Analysis is performed and appropriate graphs are used for the proper presentation of the conclusions on the issues discussed in step 7.

9. Studying the results in 7 and drawing conclusions, using 8
   Students compare their preliminary results at 7 with the most accurate, documented results at 8 and draw conclusions.

10. Review the problem and review it under more demanding conditions
    - The research can be extended to other services offered by the specific service provider or similar services offered by other providers.
    - Statistical Analysis can be extended to more complex models for predicting the degree of "customer" satisfaction with a service, according to their responses to various "important" factors (after selecting the important factors appropriately).

11. Repeat steps 5 through 8 with additional or new requirements as formulated in 10

12. Presentation of Conclusions - Communication Tactics.
    The presentation of the conclusions can be done using the technology, for presenting the need for evaluation of the services of the provider in the modern and rapidly changing environment in which we live, the important research findings and suggestions for changes of procedures or other improvement interventions needed according to the research.
    Necessary skills at this point are the creation of an appropriate electronic presentation (PPT or INFOGRAPHICS or VIDEO or PPT with voice over) but also the preparation of an appropriate detailed report that describes all the stages of the research as well as the conclusions.

13. Applications in Everyday Life - Suggestions for Developing 9 (Entrepreneurship - SIL Days)
    This activity involves representatives from a provider that provides the services under evaluation in most of the previous stages.
    The results will certainly be the trigger for the specific provider to take actions to improve and modernize the processes and services it provides. Interested students can contribute in this direction after the end of the research.

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 3 (T3) Cooperation with T1 and T2 and student guidance
A	Preparation of steps 1,2	1,2	
B	Teaching – Guidance 3,4	3,4 Meetings with the services provider representatives	
C	Teaching – Guidance 5	5	Teaching – Guidance 5
D	Guidance – Evaluation 6, 7	6, 7 Meeting with the services provider representatives	Support 6, 7
E		8	Teaching - Support
F	Guidance	9	Guidance
G	Preparation 10	10 Meeting with the services provider representatives	Cooperation in 10
H	Guidance	11 (repetition of 4-9)	Support Guidance
I	Creative Evaluation	12 Meeting with the services provider representatives	Creative Evaluation
K			
	Organization (SIL) STEAME in Life	13 Meeting with the services provider representatives	Organization (SIL) STEAME in Life

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