THE STEAME SCHOOL AND LEARNING OF THE FUTURE

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Abstract. *The project "STEAME: Guidelines for Developing and Implementing STEAME Schools" was completed recently and now several projects are producing the building blocks around it. This project became the kick-off of a paradigm shift to Education 4.0 as it provides what steps Education Systems around the world could follow in order to escape from Education 2.0 and change to Education 4.0 with learning based on inquiry and project based learning. Literature and research is showing for years now that this should be the way forward in order to help school students develop the needed competences and skills that appear to lack when they enter HE studies or enter the world of work. With today's development of digital learning most of the learning needed by school students can be easily accessible or retrieved at any time and place through digital and video learning.*

STEAME (Science – Technology – Engineering – Arts – Mathematics – Entrepreneurship) has been developed to support European teachers' knowledge and understanding of creating successful STEAME learning and creativity programs. The results are based on a European survey and a validation though focus group of experts. It offers approaches to teaching, teaching materials, entrepreneurship aspects, organizational suggestions for STEAME-oriented teaching, propositions and analysis of STEAME-oriented curriculum. All the OERs of the project are available through the STEAME Observatory. As an observatory, it is designed to be adaptive and dynamic, able to support a dynamic and adaptive STEAME Curriculum in any school that needs to implement STEAME activities in the learning process. The presentation will also show proposed architectural designs of the STEAME School of the future.

Key words: STEM, STEAM, STEAME, repository, inquiry based learning, project based learning, problem solving, skills, learning and creativity plan, observatory, evolution.

1. Introduction

Cross-national studies of student achievement (e.g. TIMSS, PISA) indicate lack of scientific competence for a considerable proportion of students. In addition to students' low achievement in sciences, there is well-documented evidence of declining interest in key STEM topics/careers for students in EU & internationally (EU Commission, 2008; OECD, 2012; European Union, 2014). Low student performance and decline in interest are of concern, since skills in STEM are among key competencies all individuals need in a knowledge-based society for employment, inclusion, subsequent learning, personal fulfillment & development. At EU level, this concern has been expressed by EU policy makers, in a series of EU summits and reports from the Education Committee (2014), culminating in the strategic targeting of resources to improve science education and ensure full participation among people from all backgrounds. Methods of instruction have been identified as contributing to students' falling interest and performance in STEM education (eg. EU Commision, 2008, [1]). Despite the extensive calls for the uptake of learner-centered forms of pedagogy focused on inquiry and problem-solving [6], changing teaching practices is proving difficult.

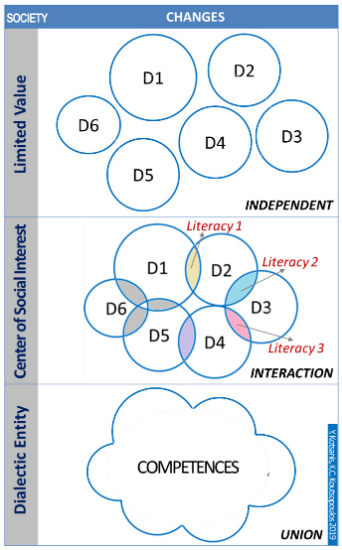

Figure 1. STEM interactions

STEAM is a developing educational model of how the traditional academic subjects (silos) of science, technology, engineering, arts, and mathematics can be structured into a framework by which to plan integrative curricula [10]. The notion of STEAM (Science, Technology, Engineering,

Arts, and Mathematics) is an emerging discipline unique in its desire to provide a well-rounded approach to education [3]. According to [4] "the independent teaching of well-defined disciplines was later replaced by their interaction producing relations, interdependences and interactions in the form of needed literacies, which finally were readjusted as their union, producing an educational entity in the form of specific competences" (Fig. 1).

2. The STEAME Project as an evolution to EDUCATION 4.0

"STEAME: Guidelines for Developing and Implementing STEAME Schools" project can be an essential part of every pupil's curriculum. It has been developed to support European teachers' knowledge and understanding of creating successful STEAME learning programs. It is also meant to assist schools in developing and implementing STEAME curricula. In a traditional school curriculum, all or most of subjects constituting STEAME are taught separately. However social, economic, political, and cultural developments of mankind take place globally and seem to demand new approaches to education and learning.

The STEM approach to teaching, together with its variants STEAM and STEAME is viewed as one of possible answers to the needs of modern society addressed at a school level system. The purpose of the Intellectual Outputs of the project was to support teachers by providing guidelines for dynamic and adaptive STEAME curriculum. The curricula, including methods and tools need to be worked out by teachers themselves. These documents and website materials, among others contain:

- **Approaches to teaching**. Lesson plans(now call Learning & Creativity plans) and other relevant supporting material to enable the educator to prepare teaching units. There are collections of worksheets and descriptions of projects that can be carried out. Furthermore, there is information on available creativity plans linked with relevant learning material that may facilitate an inquiry-based learning approach, learning based on gamification, and others.

- **Teaching Materials**. Includes audiovisual content such as videos, on the field reports, suggestions for prototypes based on reports conducted through visits to the industry itself. There are multiple links to teaching materials such as infographics and guidelines for teachers.

- **Entrepreneurship aspects**. It is of interest as it highlights what relates to the second E of the STEAME acronym, the entrepreneurship, which is an innovative perspective of this project and an evolution to learning.

- **Organizational suggestions for STEAME-oriented teaching**. Aims to make an impact on a local scale through the teacher but also on a larger scale by sparking the interest of school directors. It includes various classroom methodologies and approaches.

- **Propositions and analysis of STEAME-oriented curriculum**. Adaptability and dynamic characteristics. It provides an overview of the materials that relate to the aspect of adaptability of the curricula and is linked to its dynamics aspects emphasizing on its relations to various methodologies.

All the OERs of the project are available through the **STEAME Observatory**. As an observatory, it is designed to be adaptive and dynamic, able to support a dynamic and adaptive STEAME Curriculum in their schools. The process of adding and updating the content is a continues one, providing the opportunity to all teachers across the EU and beyond to be up to date and share their own work if they wish to. There is an open invitation to take part in the discussion in topics such as, Learning and Creativity plan (a new approach for lesson plans), posting their school's website if it relates to STEAME activities, a teacher training course on STEAME, an EU funded STEAME project, activity case studies from schools or videos of such activities, and STEAME events that have been realized or are planned to be in the future.

The **STEAME Framework** consists of the following elements:

1. Learning and Creative Methodologies (PBL-IBL-PSL)
2. Guide to Science, Communication and Presentation Students' Skills
3. Guide to Learning and Creative Plan Development
4. Learning and Creative Plan Template and Development
5. Evaluation Rubric for the implementation of a project
6. Observatory (Guide to dynamic and adaptive STEAME material)

3. Methodologies adopted by the STEAME framework (PBL, IBL, PSL)

The following three methodologies are adopted by the STEAME framework:

A. Project-Based Learning Methodology (PBL)

B. Inquiry-Based Learning Methodology (IBL)

C. Problem Solving Learning Methodology (PSL)

Project-Based Learning Methodology (PBL)

The integration of Entrepreneurship or Enterprise in STEAM to complement it and create the STEAME framework, fully responds to the requirements of PBL and enhances the possibilities of application:

- Entrepreneurship or economy–related contents will be specifically targeted and assessed and students can learn about finance, business, and marketing, and get an insight into career options. Students' voice and choice will allow them to shape their own learning with projections to their future life.
- Entrepreneurship also engages students in the development of a wide range of skills simultaneously such as problem-solving, decision making, critical thinking, communication, innovation, and teamwork, which match those sought by companies in the world of work.
- Students will create products to demonstrate mastery of content standards and the acquisition of success skills. If projects are addressed to real corporations, they are authentic. Authenticity is further brought in by the fact that entrepreneurial-based projects start from real community needs and reach out into it, connecting to local companies and policy makers.

The strong feature based on the authenticity of the learning processes and of the outcomes is strongly linked to the development of 21st century skills, which integrates PBL methodology to STEM/STEAM and STEAME frameworks. Financial, health, environmental, information and technological literacies are developed and acquired alongside more cross-curricular literacies encompassing all subjects: communication and collaboration, critical thinking and problem solving, creativity, responsibility,

social and cross-cultural skills.

Inquiry-Based Learning Methodology (IBL)

STEAM education and entrepreneurship are getting more and more closely linked than ever before. This happens in STEAME. Especially the connection between science and entrepreneurship is strong. One of the cornerstones of entrepreneurship is business idea generation. One common method of idea generation for new products or services is to design a solution to a given problem. Finding solutions to problems is a foundation of every field of science. STEAM education and entrepreneurship skills go hand-to-hand. The competences required to succeed in STEAM such as creativity, problem-solving, foresight, adaptability, are equally suited for success as an entrepreneur. Teachers must bear in mind what makes STEAME so enjoyable for many students: the desire to solve a problem. Teachers should give students the tools and skills they need to solve a problem and watch them work it out on their own.

Problem Solving Learning Methodology (PSL)

The 'problem solving' is the process to analyze a specific problematic situation and find a solution. The importance of this methodology is the ability to promote motivation, empower critical thinking and push the students to utilize everyday life skills. The teacher acts as facilitator. He/she explains how the problem solving works, leads the first interactions, shows the tools that are at the basis of each step (e.g. five W plus H, Root cause analysis and so on), illustrates consolidated examples, and helps to avoid the pitfalls. The cognitive process often drives to finding "out of the box" solution.

4. Guide to L&C Plan Development

Below is the procedure of the development of a Learning and Creativity (L&C) Plan, as developed by the STEAME project, to provide a guide to Learning and Creativity Plan.

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 v 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

Title of STEAME Project: ____

Brief Description/Outline of Organizational Arrangements / Responsibilities for Action

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

L&C Plan Template and Development

An important activity of the project was to explore more than 50+ international (EU and USA) STEM, STEAM and Project-based lesson plans and explore the elements and features that would most appropriately be suitable for a STEAME Learning & Creativity plan (L&C). Out of those lesson plans explored, and following partners collaboration, were chosen the following Projects EL-STEM, Full-STEAM, PBLWorksS STEAM4U, TeachEngineering, Ypatia, Euro-STEAM, Tolerance, Scientix, for the development process of the STEAM L&C plan template (The L&C Plan

Template is included in the STEAME Outputs, 2021).

The STEAME Learning and Creativity (L&C) plan, aims to provide teachers with the information and resources needed to implement a STEAME learning process, more than a traditional lesson. The L&C Plan consists of the following five sections:

A. **Overview** (title, driving question, ages-grades, duration, the timeline, the number of activities, brief description, contributors, references, and acknowledgements,

B. **STEAME Framework** (explained in the next chapter),

C. **Goals**, **Objectives**, Learning Outcomes, Prior Knowledge, Prerequisites, Motivation, Methodologies,

D. **Preparation and Means** (Preparation, Space Setting, Troubleshooting Tips, Resources, Tools, Material, Attachments, Equipment, Safety and Health),

E. **Implementation** (Instructional Activities, Procedures, Reflections, Evaluation/Assessment, Presentation, Reporting, Sharing, Extensions, Other Information).

Following the template finalization, the STEAME project team, developed, a prototype L&C plan, involving teachers in this process, to test and finalize, the L&C plan template. This was the basis, as a prototype and example, for the further development of STEAME L&C Plans included in the two next chapters.

The prototype L&C plan is related to how we can construct a "Customized e-Sho" (STEAME L&C Plan, 2020) studying the economics concepts of the costs, revenue and profit in a business. It consists of 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.

The STEAME project developed, 36 Learning & Creativity (L&C) plans for two categories, **grades 7-9 [ages 12-15]**, and **grades 10-12 [ages 15-18]**, related to STEAME (Science, Technology, Engineering, Mathematics, Entrepreneurship) subjects, motivating the collaboration be-

tween teachers, to achieve a multidisciplinary approach, by providing the necessary information and resources through the use of the L&C Template, that is being described in previous chapters of this report.

Evaluation of the work done for the implementation of a project

The main evaluation elements relate to how many STEAME subject are covered by the L&C plan, and how many different subject teachers are involved in its development, which competence and through which process they are developed/enhanced by the project based process including formative assessment methods which are based on rubrics extracted from related bibliography.

The STEAME evaluation is based on several rubrics and contains the following 4 main sessions (presented in the Appendix):

1. STEAME Subjects (overall performance of respective concepts/discipline/content of K-12 level)
2. Competences (knowledge, skills, values-attitudes)
3. Project Management, Development and Realization Processes
4. Formative Assessment (specified at each L&C)

STEAME Observatory

The STEAME Observatory is mainly a tool for teachers and is designed to be adaptive and dynamic, able to support a dynamic and adaptive STEAME Curriculum in schools. The process of adding and updating the content is a continues one, providing the opportunity to all teachers across the EU and beyond to be up to date and publish their own work if they wish to. There is an open invitation to take part in the discussion in topics such as, Learning and Creativity plan (a new approach for lesson plans), posting their school's website if it relates to STEAME activities, a teacher training course on STEAME, an EU funded STEAME project, activity case studies from schools or videos of such activities, and STEAME events that have been realized or are planned to be in the future.

STEAME Observatory is an international repository with selected learning objects (LOs) that is specialized to STEAM education, and comes to be added to the large family of European initiatives aiming to build thematic networks in education [11].

The structure of the Observatory is shown in Fig. 2.

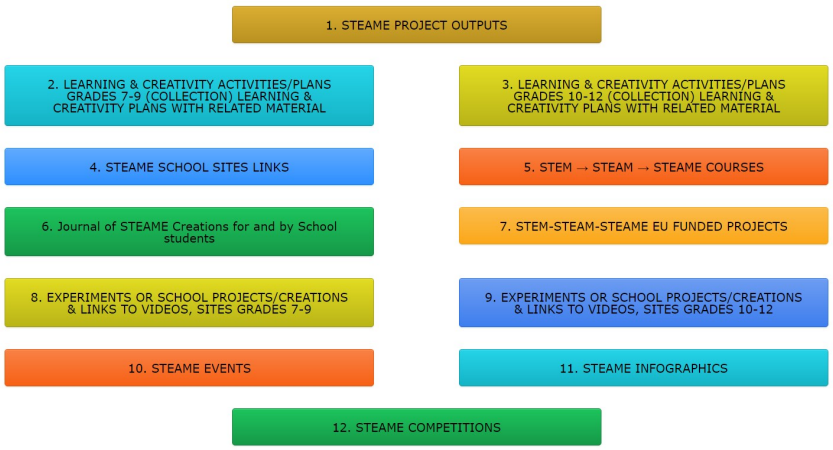

Figure 2. The structure of the STEAME Observatory

5. The STEAME School of the future

Below we present indicative photo of the design of the STEAME School of the future. Further detailed results can be found in the site website `www.steame.eu`.

Figure 3. A top view of the STEAME school of the future

Figure 4. A side view of the STEAME school of the future

The basement main content is a full set of STEAME Laboratories, VR rooms and entrances to the main amphitheatre and sports centre. The ground floor contains mainly satellite laboratories, open work space, learning stations and base entries into the small amphitheatres, reception entrance and main dual reception of the sports centre, one entrance for the school students during the day and another entrance for the community during the night, the access to the internal yard and cafeteria and more. The first floor contains open work space, learning centres, learning rooms,

a slow moving train with space for group student work, entry into amphitheatres and more. The roof contains, photovoltaics, pool recreation area, circular sport field, sports courts, roof cafeteria and restaurant and more.

6. Conclusion

STEAME, added the E (Entrepreneurship) to STEAM, aiming to engage teachers and students to STEAM activities that include the element of entrepreneurship to enable students to develop a skill that will facilitate both any future relation with the industry as part of the business world or allow them to use this skillset in aspects of their everyday professional or not, activities.

Through the STEAME Observatory that is mainly a tool for teachers and is designed to be adaptive and dynamic, able to support a dynamic and adaptive STEAME Curriculum in schools, teachers have access to the resources that will enable them to introduce STEAME activities in the learning process so students can developed creativity competences and skills. The process of adding and updating the content is a continues one, providing the opportunity to all teachers across the EU and beyond to be up to date and publish their own work if they wish to. The training course of the project guides and supports the educators to understand the essence of this approach and how to optimally introduce it to their classroom and further enhance the students' learning process.

The project partners and collaborators are listed in the project site `www.steame.eu`. The partners of STEAME project plus additional expert partners are developing several methods and resources in building blocks for the STEAME School of the future, such as BYOD-Learning, ONLIFE, Facilitate-AI, STEAME-Students and more.

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