Lighthouse Activities

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Table of Contents

1. Objective

This document aims to present the concept of a lighthouse activity and describe the main stages of the pilot phase. It is organized into five main sections.

The first section presents the rationale that led to the definition of the lighthouse activity concept, including a literature review. The second section introduces the template intended to serve as a reference document for presenting a lighthouse activity. The following section is dedicated to the pilot phase, describing its characteristics as well as the stages that compose it. Additionally, it is presented the "Observation Template" that supports the evaluation of the lighthouse activities conducted during the pilot phase. Also in this section, the template for best practices in lighthouse activities is provided, aiming to bring together the experiences and knowledge developed within lighthouse activities developed and implemented during the pilot phase and ensure the dissemination of international best practices examples. Finally, the last two sections present the references and the annex.

2. Concept of Lighthouse Activity

2.1 Lighthouse activity concept

The term "lighthouse" can be found in several areas and refers to something that serves as a guide to achieve a certain goal. For example, there are references to lighthouse initiatives and lighthouse projects to characterize innovative coordinated actions, in which several partners participate aiming to solve the needs and challenges of society.

In the educational area the term lighthouse is also used in the concept of lighthouse schools, which refers to schools that present exemplary programs of science education as the result of the involvement, collaboration, and professional and continuous development of the teachers (Blades, 2011). From the perspective of the United Nations Framework Convention on Climate Change (UNFCCC), lighthouse activities are defined as innovative and transformative solutions, offered by civil society and business partners, that address both climate-related aspects and economic, social, and environmental challenges in a given geographical area (UNFCCC, 2017).

2.2 Definition of the characteristics of a lighthouse activity

The ICSE Science Factory Project aims to use lighthouse activities to offer collaborative science learning opportunities at the local level for all citizens. These activities highlight the relevance of science for real-life challenges and contribute to a continuum lifelong learning.

Thus, it is imperative to define the characteristics of a successful lighthouse activity that effectively contributes to the promotion of students' science learning, as well as to increment their interest in pursuing scientific careers (which are also objectives of the ICSE Science Factory Project). For this purpose, it was carried out a literature review.

The literature review was conducted using the SCOPUS database, focusing on empirical studies published between January 2018 and June 2023. The search was limited to journals ranked in the 1st Quartile (Q1) in Education according to the Scimago Journal Rank. The words "STEM education", "science learning" and "scientific careers" were searched in the title, abstract and keywords.

The choice of STEM Education as a research term is justified because of its interdisciplinary character, aligning with one of the characteristics recommended within the scope of the ICSE Factory project. In addition, the understanding of science and scientific areas goes beyond the Natural and Physical Sciences. As such, mathematics, engineering, and technology also fall into this realm. Finally, STEM education had its origins in the need to attract professionals to scientific areas, which is one of its potentialities (e.g., Habig et al., 2020), in addition to improving their attitudes (e.g., Todd & Zvoch, 2019) and promoting learning (Fung, 2020).

This research resulted in 90 potentially relevant empirical studies which were read in more depth. The studies that focused on interventions with students, i.e., studies where students were involved in hands-on activities, were considered for literature review purpose (N=25) (Table A, Annex). A summary of the main findings is presented in Table 1.

Table 1- Summary of the relevant characteristics of the activities described in the selected articles.

Categories	**Number and Frequency**	**Examples**
Interdisciplinarity	N= 25 (100%)	All indicated in Table A (Annex)
Pedagogical strategies/ approaches:		
- Inquiry-based learning	N= 6 (24%)	Chen et al. (2020); Eroğlu & Bektaş (2023);
- Design-based learning	N= 8 (32%)	Bartholomew & Strimel (2018); Dasgupta et al. (2019)
- Problem-based learning	N= 5 (20%)	Chen et al. (2019); Ng and Chan (2019)
Authentic contexts	N= 3 (12%)	Roberts et al. (2018); Kitchen et al. (2018)
- Socio-scientific issues	N= 1 (4%)	Wahono et al. (2021)
Outcomes:		
Learning	N= 14 (56%)	Barak & Assal (2018); Christopoulos et al. (2023)
- Attitudes (e.g., motivation, interest)	N= 7 (28%)	Beymer et al. (2018); Vennix et al. (2018)
- Career interest	N= 6 (24%)	Cheng et al. (2021); Yoel & Dorei (2022)
Collaborative work	N= 14 (25%)	Chen et al. (2019)

The most evident aspect is undoubtedly the integration of several areas of knowledge although there are studies that emphasize the integration of specific areas such as technology and engineering. In total, in 12 of the 25 articles, the area of technology (for example, in the form of robotics, virtual reality and gamification) is evidenced through its more explicit integration with engineering (N= 6) (e.g., Dasgupta et al., 2019), with science (N= 3) (e.g., Shute et al., 2021), with mathematics (N= 2) (e.g., Ng & Chan, 2019) and with science and engineering (N= 1) (e.g., Wahono et al., 2021).

Another relevant aspect is the use of pedagogical strategies that promote the centrality of the teaching-learning process in the students, through their active involvement in design-based learning (DBL), inquiry-based learning (IBL) and problem-based learning (PBL) activities that are present in 76% of the papers consulted (Table 1). It is also evident the use of authentic contexts (12%) in many activities, some of which constitute socio-scientific issues (4%) (Table 1).

Finally, it is also evident the promotion of collaborative work in many of the reported studies (25%).

The following paragraphs provide a more detailed presentation of some of the studies included in the literature review.

Regarding the promotion of science learning, the study conducted by Dasgupta et al. (2019) with 408 students stands out. The objective of this study was to investigate the use of the Computer Aided Design (CAD) tool, Energy 3D, in the promotion of a learning anchored in the process of engineering design, which would allow to deepen knowledge of science and mathematics. Participating students had to design an energy-efficient and low-cost home, meeting a certain budget, and using the CAD Energy 3D tool. The results reveal that the students engaged in the design process, generating ideas and solutions, which they tested systematically. Additionally, students developed a better understanding of the relationships between variables and underlying scientific concepts (e.g., energy transfer in the form of heat), and used various mathematical analysis tools and graphical representations, embedded in the available technology, to justify their design decisions.

As for students' interest in pursuing scientific careers, Cheng et al. (2021), in their study of 1455 students (ISCED level 1 and 2) examined the effect of a STEM activity, with various levels of integration (i.e., based on the number of integrated areas), using 3D printing of fossils, on students' interest in STEM careers. Considering the results obtained, the authors concluded that the higher the level of integration (i.e., the more one tended towards the integration of the four STEM areas), the greater the students' interest in STEM careers.

In the case of the study conducted by Eroğlu and Bektaş (2023), the researchers aimed to investigate the effect that IBL based on the 5E model had on the academic performance of 9th graders, on scientific creativity and on views on the nature of science relating to the atomic model and periodic table. In this study participated 133 students from the 9th grade, and significant differences were found between the experimental and control groups in terms of academic performance, scientific creativity, and views on the nature of science in favor of the experimental group.

As a final example, Chen et al. (2019) aimed to explore the factors that can affect learning performance and raise awareness for collaborative problem solving. The participants were twelve 10th graders who performed a PBL-based activity that aimed to determine the reason for the eruption of Limnico, a natural disaster that occurred in Cameroon. The results were indicators of the importance of these effective learning strategies and approaches in science education.

2.3 Proposed model for a lighthouse activity

Considering the features of the studies included in the literature review, and taking into account the project's objectives (i.e., to provide collaborative science real-life learning opportunities for all citizens, by engaging learners in real-life problem-solving situations within education, the workplace and other learning environments), the key elements of a lighthouse activity are defined as being: authentic contexts, interdisciplinarity, active involvement/student-centered strategies, and collaborative work. These elements are illustrated in Figure 1. At the top of Figure 1 are included the areas that are considered as topics for the lighthouse activities (Green Deal, Digitalization and Health).

Figure 1- Proposed model for lighthouse activities.

In addition, Figure 1 includes the concept of Challenge-driven innovation (CDI) because it is implicit in the definition of lighthouse activity previously presented (UNFCCC, 2017). It refers to a strategy to promote innovation based on the establishment of well-defined objectives focused on pressing challenges of communities that require the mobilization of a set of partners to solve them (Mazzucato, 2018). In this way, through its positioning at the base of the lighthouse of the image, it is intended to highlight the role of CDI in lighthouse activities.

As defined above, lighthouse activities constitute potential promoters of students' learning, as well as their interest in scientific careers, as stated in the objectives of the project.

2.4 Organization and target group

Collaboratively, local consortium members and enterprises run short-term (several hours) interdisciplinary workshops on real-life problems for community members, thus contributing to a lifelong learning continuum for all. Our lighthouse activities will address participants of all age groups (10-15 participants). It is also possible to address more specific target groups like, for instance, people who might be skeptical about Science, senior citizens, girls, families, etc.

Lighthouse activities, as all ICSE Science Factory activities, will be free of charge during project duration. Regarding the pandemic, hybrid as well as online lighthouse activities are possible.

Local partners (full and associated partners and identified third parties) collaboratively organize lighthouse activities on real-life problems and global challenges according to community needs (as collected with the survey). In the activities, and based on our educational concept, we will have visits to the local forest to understand the impact of climate change by examining the biological properties of trees or by understanding how water transportation effects a tree and how it is influenced by climate.

These workshops will delve into pertinent subjects related to industry-funded innovation, benefiting from our extensive network of partners, and identified third parties, particularly enterprises (e.g., “What is the impact of a certain vaccination on a human being?”), thus taking participants on a journey beyond their usual sphere by leading them to comprehend entrepreneurial processes with all their benefits and challenges. With these activities, partners address different target groups (e.g., families, girls, senior citizens), contribute to society’s knowledge in science and a lifelong learning continuum for all.

Lighthouse activities will be also organized by community institutions from the consortium specialized in non-formal education. This specific setting strengthens the idea of citizen science and creates an atmosphere that might attract participants who usually refrain from such activities. A different, fun, more informal approach to scientific work provides the ideal complement to the formal providers with educational or entrepreneurial background and can reach new target groups.

Lighthouse activities also serve the purpose of encouraging schools to run open schooling activities on their own, being an inspiration and model for them: for instance, in a lighthouse activity the school community (including teachers, students, families, community members) is informed about smart consumption. Afterwards they interview other community members on their cloth buying habits and how they could reduce the number of buying new cloths. They also collect old clothes to reduce waste and find a new purpose for it: producing pencil-cases, furniture, art, or printing school logos on redesigned clothes. Afterwards, based on their results, they write recommendations for the community on smart consumption.

In Table 2 a summary of the principal characteristics of lighthouse activities is provided.

Table 2- Summary of the relevant characteristics of lighthouse activities.

Characteristic	**Description**
Type of activity	Interdisciplinary workshops on the three project topics (Green Deal, Digitalization and Health)
Duration	Short term (several hours)
People involved	10-15 participants from the whole community: all age groups, also possible to address to people who might be skeptical about science, senior citizens, girls, families, etc.
Initiation and choice of the topic	External stakeholders and universities who offer the activity.
Aim of the activity	Supposed to convey fun of science, but also help to understand it.
Connection between lighthouse activities and Open Schooling	Lighthouse activities can be the kickoff for an Open Schooling activity. Can encourage and inspirate Open Schooling to run a project that evolves around the same topic.

Additionally, in the Annex (Table B), lighthouse activities and Open Schooling are compared.

More details on Open Schooling can be found in the corresponding document (WP2/ Open Schooling).

3. Template for a Lighthouse Activity

This section presents a template intended to serve as the reference document for the presentation of a lighthouse activity.

Lighthouse Activity

[Please provide the name of the Lighthouse activity]

Partner(s) involved in designing the Lighthouse Activity

[Please provide the name of the partner(s) involved in the Lighthouse activity]

[Please add the date]

- Topic (please indicate with an “X”)

  Environment/Green deal ___
  Health ___
  Digitalization ___

- Interdisciplinarity (please indicate the subjects involved): ____________________________
- Approximate implementation duration: _______ min
- Target Age: ___________
- Brief description of the Lighthouse Activity

4. Pilot Phase

4.1 Pilot Phase

- **Aims**: The pilot phase aims to test and evaluate the lighthouse activities, gathering information during the participants' engagement in the activities. These results are intended to optimize and improve the lighthouse activities for the project implementation phase, as well as to describe the international best practices example.
- **Number of lighthouse activities**: In the pilot phase, each partner country will test a minimum of 3 and a maximum of 9 lighthouse activities in their local context.

- **Duration**: The pilot phase takes place between 15th November until end of March.
- **Areas**: Each one of the activities was conceived to address one of the areas of the real-life challenges:
  → Environmental issues - Green Deal
  → Digitalization
  → Health

  A lighthouse activity may involve more than one of these areas, but it is categorized according to the specific knowledge area that is mainly intended for participants to develop.
- **Indicators:** number of participants in lighthouse activities (on average 10-15 participants per activity)
- **Stages:** The pilot phase is based on the four stages of the Design-Based Research (DBR) approach: i) Design; ii) Test; iii) Evaluate; and iv) Reflect (Figure 2).

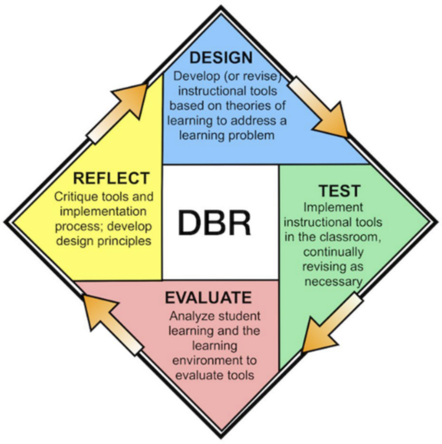

Figure 2 – Four stages of the Design-Based Research (Scott et al., 2020)

Stage 1.
Design – the design of activities should start from the definition of a problem, contextualized in one of the areas identified above (Green deal, Digitalization, Health).

It is important to understand all aspects of the problem in order to provide an understanding of the context in which the activity will take place. It is essential to consider theoretical knowledge and the appropriate context for carrying out the activity.

Stage 2.
Test – The piloting of the activities (3 to 9) begins at this stage. In the specific case of ISCE Factory, the development of this phase will take place simultaneously with the next phase (Evaluate).

Stage 3.

Evaluate – The purpose of this phase is to evaluate the implementation of the activities by the participants, with the aim of optimizing and improving their design and implementation processes to be executed in the 'implementation phase' of the ISCE Factory project.

The lighthouse activities will be evaluated using a semi-structured observation guide (next section). This guide comprises 7 evaluation dimensions and will allow the analysis and reflection on the results of all partner countries in the next DBR-phase (Reflect) and, consequently, to improve the activities to be implemented later. Additionally, the data collection will be also useful to describe the best practices examples.

Stage 4.

Reflect – In this phase, the results of the application of the lighthouse activities during the pilot phase of the Project will be analyzed, followed by a subsequent reflection by the local partnership as well as the European Consortium. This will make possible to identify the necessary improvements to be made to the activities, both in terms of their design and in terms of the processes carried out by the participants.

This will start a new cycle of improvement, as advocated in the DBR.

IMPORTANT NOTE:
Prior and after the implementation of the activities, partner countries should provide the pre- and post-test evaluation questionnaire, respectively (developed in WP5).

4.2 Observation template

The purpose of gathering data following the "Observation Template" is to support the evaluation of the lighthouse activities conducted during the pilot phase of the project and, consequently, facilitate their future improvement. Additionally, the collected data will be valuable in illustrating international best practices.

The focus of this observation is on both the participants and the activities themselves. Specifically, dimensions A (Conceptual knowledge), B (Skills), and C (Difficulties experienced), described below, are intended to collect data on the conceptual knowledge and skills that participants develop during the implementation of the lighthouse activity. Dimensions D (Relevance), E (Consistency), F (Practicality), and G (Activity effectiveness), on the other hand, aim to gather data on the relevance, consistency, practicality, and effectiveness of the activities.

Next, a template intended to serve as the reference document for the observation of the lighthouse activities implementation is presented.

Observation Template

[Please provide the name of the Lighthouse activity]

[Please provide the name of the observer]

Date:
Local:
Partners involved:
Target group:
Number of participants:

A. Conceptual knowledge

The activity promotes the development of conceptual knowledge

Theme	**Field notes**
Environmental issues - Green Deal	
Digitalization	
Health	

B. Skills

The activity promotes the development of skills.

Skills	**Field notes**
Attitudes	
Skill in mobilising knowledge	
Communication skills	
Creativity	
Formulating hypotheses	
Appropriate use of technology in solving the problem/challenge	
High order thinking skills (decomposition; abstraction; pattern recognition; error detection; ...)	
Critical thinking skills	

C. Experienced difficulties

The participants experienced difficulties.

Difficulties	**Field notes**
Overall level of difficulty	
Application of concepts	
Specific actions / processes	
Understanding of the problem / challenge	
Create or identify a valid solution to the problem / challenge	

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D. Relevance

The activity is relevant.

Relevance	Field notes
Relevance of the activity according to its objectives	
Applicability of mobilised knowledge to real-life contexts	
Engagement of the participants in the activity (active participation, questions asked, and discussions generated)	
The different subjects are considered and well articulated in the implementation of the activity.	
The activity in its implementation promotes collaborative work between participants.	

E. Consistency

The activity is logically designed.

Consistency	Field notes
Clarity of procedures	
Coherence with the objectives to be achieved	
The activity follows a logical and coherent flow with stages well connected.	
Adequacy of resources, support and instructions	
Time allocated for the activity is adequate	

F. Practicality

The activity is usable in the settings for which it has been designed.

Practicality	Field notes
Allows areas of knowledge to be integrated and mobilized	
Enables the application of competences / skills	
Accessibility of resources	
Time needed to carry out the activity	
Adequate Complexity	
Suitability of space	
Cost	
The activity can be adapted to different contexts or groups of participants	

G. Activity effectiveness

Using the activity results in the desired outcomes.

Effectiveness	Field notes
The activity is aligned with the specific objectives it aims to achieve.	
The activity is implemented consistently and according to the initial planning.	
The activity intervention has a long-term impact on the participants. The effects last beyond the activity itself.	
Participants' satisfaction with the activity	

4.3 Best practice lighthouse activities template

- **Aims:** To bring together the experiences and knowledge developed within lighthouse activities developed and implemented during the pilot phase and to ensure the dissemination of international of best practices examples.

  The specific objectives are:

  1. To accommodate and support exchange of knowledge and mutual learning among ICSEFactory partners about of international of best practices examples concerning lighthouse activities.
  2. To integrate and synthesize all best practices examples concerning lighthouse activities into recommendations and documentation that exemplifies and guides other schools and communities of practice interested in the development of lighthouse activities.

- **Procedures**

  During pilot phase:

  → Each country will describe a best practices examples concerning the lighthouse activities developed and implemented during the pilot phase (three activities corresponding to one per area).

  → The best practices examples must be prepared by each country with the information collected through the observation guide.

  → The best practices examples describe the knowledge/expertise produced during the development and implementation of the lighthouse activities (students' development knowledge, skills and attitudes, experienced difficulties, activities' relevance, consistency, practicality and effectiveness, obstacles, possible solutions, different processes, etc.).

- **Guidelines**

  The best practices examples will focus on the lighthouse activities developed and implemented during the pilot phase, covering the following topics:

  1. Description of the activities carried out (their learning objectives, the topics included, their main characteristics, and the possibilities of interdisciplinary integration).
  2. Description of the implementation process of the lighthouse activities:
     a. Context in which it was implemented – information about the participants and partners' collaboration/involvement.
     b. Location where the activities were implemented and duration.
     c. The different people involved (partners and their role and level of involvement).

d. The role of the learners.
e. How they were implemented.

3. The knowledge, skills, and attitudes developed by the learners.
4. The difficulties experienced by the learners and the strategies developed to overcome these difficulties.
5. The key success factors of the lighthouse activities.
6. Our perspectives on the relevance of the lighthouse activities.
7. Overall assessment: final reflective remarks.

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6. Annex

Table A- Main characteristics of the selected articles.

Authors/year	Country	Study design	Educational level (ISCED level)
Vennix et al. (2018)	The Netherlands/ USA	Quantitative	2 and 3
Roberts et al. (2018)	USA	Qualitative	1 and 2
Barak & Assal (2018)	Israel	Mixed	2
Bartholomew & Strimel (2018)	USA	Mixed	1 and 2
Beymer et al. (2018)	USA	Mixed	1 and 2
Kitchen et al. (2018)	USA	Quantitative	3
Ng & Chan (2019)	Hong Kong	Qualitative	1 and 2
Dasgupta et al. (2019)	USA	Quantitative	1 and 2
Chen et al. (2019)	Japan	Mixed	3
Shahali et al. (2019)	Malaysia	Mixed	2
Zheng et al. (2020)	USA	Quantitative	2
Heras et al. (2020)	Spain	Mixed	3
Chen et al. (2020)	Taiwan	Quantitative	3
Schmidt et al. (2020)	USA	Quantitative	1 and 2
Cheng et al. (2021)	USA	Quantitative	1, 2 and 3
Chang et al. (2021)	Taiwan	Quantitative	2
Wahono et al. (2021)	Indonesia	Mixed	2
Shute et al. (2021)	USA	Quantitative	2 and 3
Yoel & Dorei (2022)	Israel	Mixed	3
Shanta & Wells (2022)	USA	Quantitative	3
Ladachart et al. (2022)	Thailand	Mixed	2
Eroğlu & Bektaş (2022)	Turkey	Quantitative	2
Cheng et al. (2023)	Taiwan	Quantitative	2 and 3
Baptista & Martins (2023)	Portugal	Qualitative	2
Christopoulos et al. (2023)	Finland	Quantitative	3

Table B- Summary and comparison of the relevant characteristics of lighthouse activities and Open Schooling.

Characteristic	**Lighthouse activities**	**Open Schooling**
Type of activity	Interdisciplinary workshops on the three project topics (Green Deal, Digitalization and Health).	Interdisciplinary projects on the three project topics (Green Deal, Digitalization and Health).
Duration	Short term (several hours)	Long term (several days, weeks, months, years)
People involved	10-15 participants from the whole community: all age groups, also possible to address to people who might be skeptical about science, senior citizens, girls, families, etc.	5-8 participants from school community: students, teachers, external stakeholders, parents, community members.
Initiation and choice of the topic	External stakeholders and universities who offer the activity.	The whole project group.
Aim of the activity	Supposed to convey fun of science, but also help to understand it.	Supposed to work scientifically on real-life problems in their own community/school.
Connection between lighthouse activities and Open Schooling	Lighthouse activities can be the kickoff for an Open Schooling activity. Can encourage and inspirate Open Schooling to run a project that evolves around the same topic.	