urban science

Research and Review into Opportunities and Barriers

SUMMARY REPORT

Urban Science – Integrated Learning for Smart Cities

Over two-thirds of the European population live in cities. Enabling those cities to deliver services sustainably while keeping their citizens safe, healthy, prosperous and well-informed is amongst the most important challenges in this century. The Urban Science European project is an education response to this, to improve the teaching of scientific inquiry and investigation so that pupils develop the competences to actively contribute to creating healthy cities, gain scientific skills to enter the world of work, and meet the demand for the urban scientists of the future. Urban Science works through outdoor inquiry-based learning where urban areas become living-laboratories that help pupils explore how science can create healthier and sustainable places to live. It is solutions based; placing a strong emphasis on creativity and problem solving to ensure scientific understanding can be applied in a meaningful context. The project draws on several influences in inquiry-based learning and an understanding of how the natural world provides a systems model for sustainability. Critical to the success of the project is weaving together the needs of curriculum in the partner countries, teacher competences and learner profiles. This article provides an exploration of the development of the learning framework the project is developing, how this builds on recent work in the field, and adds value to the increasing call for and need to educate pupils in scientific literacy for a sustainable future.

Urban Science is funded by the European Union Erasmus+ Programme

Co-funded by the Erasmus+ Programme of the European Union

The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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1. Summary of research done

A range of different methods were used for the initial research in the countries: online surveys, Delphi research, discussions with experts and practitioners, meetings with teachers from associate schools, desk research on the national educational policy documents, curriculum standards and programs, literature about sustainable cities, science education, inquiry based science learning, outdoor learning, relevant projects and initiatives – both national and international.

In total 233 teachers and practitioners were contacted online, 32 of teachers and 55 experts contacted face-to-face during interviews, school visits, meetings with associate school teachers, educational events and conferences.

2. Summary of barriers and opportunities recognized, including all investigation areas

Strengths	**Weaknesses**
• Inquiry-based learning approach is known to the teachers and viewed positively as way to engage students (UK, HU, PL, LV). • Outdoor learning is often used by teachers or is an integral part of curricula. Most of the teachers interviewed are confident to and do use local (including urban) environment for teaching. Teachers regard the urban environment as an interesting space for teaching. Urban environment is rich of stimuli for learning. (UK, IT, HU, LV, PL). • Programme to Support the Education for Sustainable Development was worked out and explicitly present in all policy documents in Hungary and Bulgaria. Teachers have experience in and motivation for working with sustainability topics, ESD tools and methods. • Interdisciplinary learning is practised in schools and teachers from different subjects cooperate in different ways (LV).	• Time issue (lack of time, limited time, overloaded curriculum, lack of short outdoor activities etc.) is mentioned in all countries conclusions in one or another way. • Lack of interdisciplinary teaching is another issue, mentioned in almost all reports. Even if in some countries (LV) most of the teachers responded they use interdisciplinary teaching, this approach currently is mostly initiative of particular teachers at individual schools, not universally accepted practice. • Teachers' sustainability competences are weak or limited, not all aspects of sustainability are integrated in the teaching practice. (HU, UK) • Italian partner underline several constraints to outdoor learning – permissions from parents needed, additional teachers, organisation of transport, security, objective dangers. • Local context is not really present in the lesson scenarios or activities planned (PL), themes of curricula have little relations to real life (LV).

Opportunities	Barriers
• The need to connect learning with everyday life and to use local community more within teaching (UK, IT, PL, HU, LV). • Inquiry learning (working scientifically) or project based learning (UK, LV, PL, HU, BG). • Development of soft (personal, social) skills, including ability to take on new challenges and rational pro-environmental and social activities, skills for citizenship (PL, IT, LV) • Plenty of different opportunities to include investigations of the urban environment in different natural and social science subjects. The most opportunities had seen in geography, but also in biology, physics, chemistry, mathematics. Different extracurricular activities like excursions to enterprises, science day in the city etc. were suggested. (LV)	• Amongst the main barriers is time – overfull curriculum limits outdoor opportunities (UK, PL, IT, HU, LV). • Administrative burden in organizing outdoor trips and administration for risk assessing for outdoor learning (UK, IT, BG, LV, HU). • Too many students in class, student's behaviour or traditions to see excursions and field trips as "walking", not learning. (LV, IT, BG) • Limited interdisciplinary teaching. Limited collaboration opportunities between teachers of different subjects (UK, HU, IT) • Lack of quality teaching materials, ready to use or easy adaptable lesson plans, lack of equipment and funding for extra activities and project work (LV, BG) • Curriculum is not fitted to make links between what is being learnt in school and its practical application (BG) • Extra costs for trips, extra work for teachers for preparing outdoor activities (IT, LV) • Present educational policy (strict central control) and political environment are disempowering teachers and discourage innovation in teaching. (HU) • Persistence of the habit of the frontal lesson. • Inadequate teacher training. (IT)

3. The Urban Science student

We asked what the 'dream Urban Science student' might look like. We sought to clarify the competencies our learning needs to develop if students are to actively participate in creating healthy and sustainable cities.

Inquirer - explore ideas and theories
Innovative: creative and reflective
Open-minded
Divergent
Caring
Hopeful

Complex (holistic) thinker
Critical thinking skills
Autonomous
Team player
Engaged
Has good communication skills
Can solve real-life challenges
Responsible member of society - participates in the life of local community

4. Themes, topics and issues

Connecting Urban Science with the curriculum in each country is important, and linking with existing initiatives in which teachers have trust. This research area sought to identify which topics, themes and issues might best support teachers and be relevant for students.

Partners investigated the best "entry points" in the curriculum and topics which could be interesting for teachers to include in their teaching.

Several partners reported importance to connect Urban Science project with learning for sustainability or UN Sustainable development goals (UK, IT, HU). Teachers see also links with the notion of 'science capital' (UK). Some common concrete topics emerged in several countries - waste management, biodiversity, ecosystem services, green areas, nature protection. Urban Science model seems to be in line with the concept of a school open to the society (IT) and engaging students' families and the local community to support learning (LV). There was also interest from teachers to use Urban Science approach for improving practical science 'enquiry' skills (UK, LV, IT).

Teachers think that all disciplines can be considered for using urban environment as a learning laboratory. Geography, biology, earth sciences, chemistry, computer science, natural science and physics, history, math, art and technology and citizenship are reported as disciplinary areas that can be effectively developed. Extra curriculum classes are also seen as possibility (BG, UK, LV).

Two approaches were explored and are described as a 'Full' and a 'Practice' model (UK):

- 'Full' model - Can be used to fully illustrate ideas about 'enquiry based learning' in urban environment for example in STEM Clubs or Science week
- 'Practice' model - Easy to integrate into the mainstream KS3 KS4 Science curriculum. Can be used both as a scaffold and as practice for 'required practical' assessments

Similar idea emerged from the research in Bulgaria – we will need to create one learning pack that includes activities that fit to the *compulsory curriculum classes* by making connections, where they don't exist, between the different parts of the study plans and programmes and a

second learning pack (LP2) that is suitable for *extra curriculum classes*.

5. Important concepts

This area of research asked what concepts within science and sustainability are important to integrate into the learning, both in terms of realising the goal of sustainable cities and quality IBSE. Below is a discussion of ideas emerging from the research.

As mentioned in the previous section, in UK there are clear links with the Sustainable Development Goals (SDG) which has resonance with some schools; WWF has mapped the SDGs against key urban themes (food, transport, etc) and it will be possible to map Urban Science learning against both. Partners from Poland were also looking at the place of SDGs in Polish education and found out that urban topics are not covered yet, so it could be something new to focus on.

Very important suggestion from teachers in IT is that US project should outline learning modules and teachers training near to the real situation of schools and remember the weakness and the barriers reported above in this report and give guidance and help to inspire a new way to teach science.

When asked to assess their familiarity with concepts of circular economy, system thinking, biomimicry, systems science and citizen science in Bulgaria, the answers shows very little number of teachers using these concepts in their teaching. We should focus on these concepts in our training.

Several partners looked in to other similar project experiences for example Motivate and Attract Students to Science (www.mass4education.eu) and particularly the question "What are the main factors which influence attractiveness of science lessons?" Outcomes show that there are 4 main factors attracting students to science: use of ICT tools; use of experiments, field observations and research; implementation of different teaching methods; practical application of theoretical knowledge.

The previous wide research about of the state of the art of science education in Hungary was mentioned and the most important lessons learnt:

- when given appropriate support, teachers are willing and able to work with complex ideas, linking inquiry-based science learning and sustainability
- in these cases, collaborations were formed within the local communities
- the concept of living laboratories started working after at least 6 month of mentoring support from researchers and experts to teachers

- teachers are eager to share.

The concept of circular cities was investigated (*Circular Cities: Mapping Six Cities in Transition*). Ellen McArthur foundation in its 'Vision for Europe' outlines three key principles of circular cities: *preserve and enhance natural capital, optimize resource yields and foster system effectiveness*. Six business actions that translate these three principles into concrete actions are described: *Regenerate, Share, Optimize, Loop, Virtualize and Exchange (ReSOLVE)*.

The importance of community in the concept of the circular city was stressed by the experts in Latvia as well as focus on the simple actions which make sense for students and improve their personal life in the city.

6. Other important information

Majority of teachers who answered the questionnaire in Italy were positive about the outdoor science, interdisciplinary work in their school, importance of science education for a sustainable future. They evaluate positively the possibility in the future to teach science using the urban environment as an educational resource pointing out the needs for facilitating this transition: training, possibility to involve other colleagues, more time in their teaching schedule for it, simplification of the organization issue and more knowledge about what are the resources in the environment near the school.

The importance of teacher qualification and training as well as working in teams and collegiality was mentionned also in the research *Science Education in Europe: National Policies, Practices and Research* and Research on the quality of science education by the Nuffield Foundation studied by Latvian team. The most important competencies necessary for a science teacher, pre-service and in-service teacher education and professional development strategies and programs to enhance science teacher skills which could be considered for Urban teacher training and support are compiled in the report (see full report).

7. Good practice/initiative

16 good practice initiatives (local, national or international), connected to science education or urban sustainability projects were described analysed by partners. These are available in the full report which will be sent on request.

8. Success criteria for use of the urban environment for teaching science

Based on our research we established a list of success criteria to guide our work. A condensed version was created by the partners and form the centre of both our development of learning resources and monitoring & evaluation of project results.

1. Pedagogy:

- Strengthens confidence of teachers to deliver inspiring science lessons that relate to the everyday lives of their pupils and to developing healthy cities.
- Promotes interaction between pupils and their urban environment.
- Focuses on working scientifically and science competences
- Connects classroom based learning with the world of work.
- Increased progress and attainment of pupils in science
- Increases student's interest in urban themes.
- Scenario of the activity includes practical application of theoretical knowledge.
- It fills the gap between theory and the real world giving students the possibility to apply what they study, to research on their own and to decide their style of life.
- Bridges the gap between school science reality and the students' experiences and environment.
- Different teaching methods, incl. experiments, field observations and research, are used to make lesson more attractive.
- Uses techniques of inquiry-based science learning (e.g. design-based, project-based, research-based learning, collaborative learning).
- Empowers teachers to create or adapt Urban Science modules.
- Develops students' (life and science) skills in the context of science learning and sustainability.
- Inclusive for all students including marginalized groups and gender.
- Science and technology are not just subject to study for the sake of them: with US science and technology provide a red thread and a frame to understand the place where we live and the challenges we have to face.
- It promotes active engaging and action.
- It develops relevant issues for students.
- Students can link their local urban themes to a more complex and global pictures.
- It makes science and technology alive and near to their life, as necessary and appealing "instruments" to use for understand and to think how to improve environmental challenges.
- It promotes responsibility towards the place where we live and study.
- Innovative, creative
- Strong focus on formative assessment and tracking progress.
- Increases confidence, motivation and engagement in lessons
- Builds on existing and increases skills and knowledge
- Interdisciplinary and integrated
- It empowers students for their future.
- Outputs of activities need to ignite curiosity;

2. Curriculum

- Develops subject knowledge and understanding of areas of curriculum.
- Improves pupils progress in science knowledge, skills and/or understanding
- Increases understanding of urban science issues.
- Increased ability to apply competencies to challenges for creating healthy cities and a low carbon economy.
- Aligns with Schemes of Work and Programme of Study.
- The formula and content of the activity help students choose their career and develop their professional predispositions – it connects school based learning with the needs of the real workplaces.
- Links urban themes included in the curriculum with outside curriculum issues.
- Links science, math, technology, art content and topics to sustainability and vice versa.
- Improves students' science competences.
- Increases understanding of urban science issues.
- It is open to innovation and it is up to date in relation to sustainability issues.
- It links the curriculum with resources of the territory
- Connected with real life, local and wider society.
- Developing scientific competencies – inquiry, research, scientific language, and argumentation.

3. Topic/subject:

- Scenario is related to the issues relevant to the community and the environment in which students live – it promotes interaction between the youth and local community.
- LPs should offer content not only for the urban population but also for students in rural areas;
- Ecosystem services
- Biomimicry
- Biodiversity
- Quality of life
- Sharing economy
- Empty spaces
- Food in the city
- Transport in the city

4. Mode of delivery

- Provides opportunities to inspire girls and boys equally.
- Small scale actions, personal to students.
- Improves technical skills for supporting practical work
- It includes examples of short and simple outdoor activities which could be implemented in the limited time in the close neighbourhood.
- In the activity ICT tools, incl. mobile apps, are used.

- Gives opportunity for students to develop their creativity and sharing the results in the outside classroom environment.
- Activities need to include 'peculiar' questions that bend the usual way of thinking and information intake; and, factsheets with unusual information;
- Activities need to provoke creativity and teamwork; possibility also for individual work
- Focuses both on individual engagement and team-work, empowering student autonomy.
- Links learning with careers and practical application of science.
- It is accessible for anybody (i.e. to students that have difficulties, disadvantaged) and affordable for any school (from both economical and bureaucratic points of view) and any teachers (it supports teachers not only with ready to go activities, but with pedagogical strong and easy method examples to inspire their own work, give clear tools to assess their teaching work, empowering teachers to deliver an effective and interesting science teaching.
- Positive
- Uses diversity of methods and activities
- Personally important , involving every student
- Involving in the decision making
- Connected with local and wider society – family members, community, experts, entrepreneurs, NGOs to support learning
- Teamwork – students, teachers, school administration
- Simple equipment available

5. Structure of the resources:

- LPs need to include detailed learning objectives, teaching methodology, and, assessment and evaluation tools; Clear target and result
- LPs need to have clear activities/tasks cascading knowledge;
- LPs need to be written in clear and comprehensive language;
- LPs need to include clear images;
- Learning with mobile applications;
- LPs should include complex research tasks that require 1 school term to complete;
- LPs should provide activities that could be used independently from the complete methodology;
- LPs need to include numerous worksheets for out-of-the-classroom activities;
- LPs need to include health and safety measures;
- Offers accessible outdoor learning experiences with clear curriculum links.
- Support and guidance tailored to the 'real' curriculum in schools.
- Aligns with Schemes of Work and Programme of Study.
- Learning modules 'chunked' to increased integration into existing Schemes of Work.
- Improves sharing of effective practice and resources in science
- Easily accessible and searchable from different perspectives (e.g.: age groups, main topics, teaching methods).
- Creates a legible platform.

- Supports and encourages adaptation over cookbook-like copying.
- Improves sharing of effective practice and resources in science
- LPs need to be interactive and practically orientated;

6. Other important criteria

- Improves knowledge and skills in leadership and management outdoors.
- Improves leadership of science curriculum
- More pupils considering studying science at a higher level and/or considering a science related career.
- Positive change in awareness levels amongst pupils towards science study and science careers.
- Inquiry and research equipment to be easily accessible/affordable.
- All modules are piloted by teachers in real schools and reflected on.
- Improves decisiveness and taking initiatives in students to improve their future environment.
- Encourages students to use scientific evidence for decision-making and problem-solving.