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PULCHRA

Participatory Urban Learning Community Hubs through Research and Activation

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D3.1 Report on the science education methods and approaches to be used

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Table of Contents

Executive summary

This document is the Deliverable 3.1 of the PULCHRA project aiming on the reporting on the science educational methods and approaches to be used in the project, including an assessment of methods and approaches already in use. In addition, an inventory of open access educational resources on Open Schooling as used in the European Union countries and at the international level, in the past and currently is created; similarly regarding science education methods and approaches. Best practices are recognized and described.

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Version	Date
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Part A: Science grounded in students' inquiry

Why Inquiry based learning

Inquiry-based learning is regarded as a vital component in building a scientifically literate community (European Commission, 2007; National Research Council, 2000) as it aspires to engage students in an authentic scientific discovery process.

A growing body of educational research suggests a myriad of conceptual models and approaches that promote inquiry-based learning and genuine knowledge creation. From a pedagogical perspective, the complex scientific process is divided into smaller units called *inquiry phases* forming the *cycle* of *inquiry* that guide students and draw attention to important features of *scientific reasoning*.

Learning through approaches which reflect the authenticity of science as practised by scientists creates a more engaging learning environment and its positive impact on students' ability to understand core concepts and procedures is widely recognized. It is also seen as a possibility for engaging underrepresented students in science learning.

Which inquiry learning cycle model is to be adopted

The model that will be used in PULCHRA reflecting a contemporary view of inquiry-based learning is derived from a systematic review of inquiry-based learning frameworks found in the literature (Pedaste et al, 2015). The advantage of this framework is the following: it provides structure for the complex inquiry-based learning and the necessary guidance in order to enhance the efficiency of the learning process.

An inquiry cycle usually follows an ordered sequence of phases. However, researchers usually stress out that inquiry-based learning is not a prescribed, uniform linear process. The selection and/or arrangement of inquiry phases can be influenced by the way in which scientists choose to balance inductive and deductive approaches in an inquiry cycle. Thus, the sequence of the phases in the inquiry cycle can depend on the nature of the problem under investigation. Since the terminology used by different researchers to label the phases of the inquiry cycles may differ, yet in their essence they are the same, defining unique and conceptually independent inquiry phases is of major importance.

The inquiry-based learning under the adopted model includes five distinct general inquiry phases: *Orientation, Conceptualization, Investigation, Conclusion, and Discussion*. These terms have been extracted as core terms from the reviewed literature, and they cover the processes behind most of the inquiry phases described in 32 articles which were selected. Using this framework in PULCHRA is intended to provide conceptual and structural guidelines to develop and organize the teaching materials and school projects.

Typically, observation or exploration of different phenomena in the environment stimulates curiosity and interest to continue searching for the truth. Reading or learning about some scientific concepts and/or theories transfers the general inquiry interest into focussed, scientifically oriented questions related to a particular phenomenon, the learner being oriented towards a well-focused issue. Therefore, the outcome is the problem statement. Consequently, the first inquiry phase in the cycle should be *Orientation*.

The inquiry continues with more specific questions, the research questions, which can be formulated and then addressed with the scientific method. However, these questions might be specific, discipline-oriented or more open about a particular domain. Despite the differences in the terms used in literature, a hypothesis, researchable assumption or prediction is needed before the learner starts planning an investigation. Overall, the processes of formulating questions and generating hypotheses overlap. The outcomes represent research questions or hypotheses to be investigated or both. Obviously, these processes facilitate the development of a research approach. Therefore, *Questioning* and *Hypothesis Generation* are sub-phases of a more general inquiry phase namely *Conceptualization*.

The *Investigation* phase starts with planning or designing the experiments and identifying resources needed to address the research questions or test the hypotheses. The *Investigation* thus is the third general inquiry phase after *Orientation* and *Conceptualization*. Two types of investigation processes are highlighted in the literature: *Exploration* and *Experimentation. Exploration* may be understood as a process where students make discoveries related to their research questions without a clear hypothesis in mind. *Experimentation* follows a methodological defined procedure or protocol with a specific timeline where evidence regarding a research question or hypothesis is collected. Both *Exploration* and *Experimentation* involve *Planning* and require collection of data.

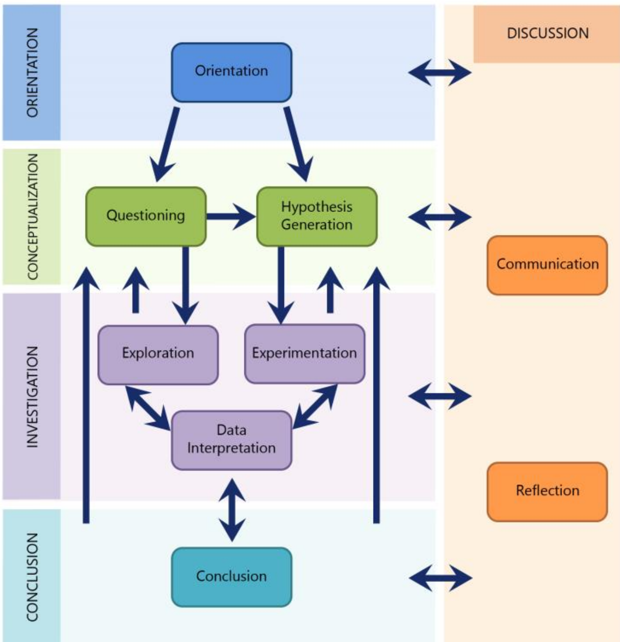
Data collection is not limited to the numerical data but includes all kinds of observations or data pertaining to the research task. *Data Interpretation*, a process that assigns meaning to the collected data, is included as a sub-phase of the *Investigation* phase. The interpretation of the data represents the final outcome of this phase and could lead to revising an experimentation plan or stimulates additional explorations: as a result, learners could move backwards and forwards as necessary.

Conclusion is seen as the fourth phase of the framework where the basic conclusions, based upon evidence, analysis and evaluation, are stated. The evidence originates from the personal observations or experiments and from other sources such as literature or textbooks as long as they follow a transparent and reproducible, at least in principle, approach. Conclusions refer to the original research questions or hypotheses and state whether these are answered or supported by the results of the study. Thus, conclusions should be directly linked to evidence.

Discussion can be seen as a separate final phase of the inquiry cycle. Sometimes, discussion is seen as a phase that is conducted in parallel with *Conclusion*. However, for reasons of contextual and structural clarity these two phases *Conclusio*n and *Discussion* should be separated. *Discussion* involves a critical reflection of the approach which is used in order to evaluate and explain the validity and uncertainties of the results.

Therefore, statements provided in the *Discussio*n phase can be opinions or assumptions, which may not be supported by evidence. However, the ability to reflect upon and understand limitations of the research and research results represents an important objective for teaching and learning science, essential for recognition of the next research step. Furthermore, this ability enables students to critically assess the validity and significance of statements found in the media. As an intended side-effect, it also builds trust in the method of science.

As part of the learning process, the *Discussion* phase includes *Communication* and *Reflection*. *Communication* takes place between learners and peers/teachers concerning the outcomes and *Reflection* is seen as an inner discussion of the learner concerning the processes. The oral or written communication generates support for research. It serves the purpose of informing different stakeholders including scientists. *Reflection* is a process of describing, critiquing, evaluating and discussing the whole inquiry cycle or a specific phase. It is defined as the process of reflecting on anything in the learner's mind, e.g., on the success of the inquiry process or cycle, while proposing new problems for a new inquiry cycle and suggesting how the inquiry-based learning process could be improved.



Inquiry learning framework (Pedaste et al, 2015)

Students may follow different pathways[1] in the inquiry-based learning process as following:

(a) *data-driven approach* where students explore a phenomenon according to a general plan starting from more open question(s)

Orientation – Questioning – Exploration – Questioning – Exploration – Data Interpretation – Conclusion (the loop between Questioning and Exploration can be repeated several times, but it is also possible to move directly from the first Exploration to Data Interpretation; Communication and Reflection can be added to every phase);

(b) *hypothesis-driven approach* where students have a theory-based idea about what to investigate

Orientation – Hypothesis Generation – Experimentation – Data Interpretation – Hypothesis Generation – Experimentation – Data Interpretation – Conclusion (the loop between Hypothesis Generation – Experimentation – Data Interpretation can be repeated several times, but it is also possible to move directly from the first Data Interpretation to Conclusion; Communication and Reflection can be added to every phase);

(c) *question-driven approach* where students based on their question collect background information for stating a specific hypothesis as a possible answer to the question.

Orientation – Questioning – Hypothesis Generation – Experimentation – Data Interpretation – (Questioning) Hypothesis Generation – Experimentation – Data Interpretation – Conclusion (the loop between Hypothesis Generation – Experimentation – Data Interpretation can be repeated several times, but it is also possible to move directly from the first Data Interpretation to Conclusion; after Data Interpretation it might be necessary to revise Questions, but more often only Hypotheses are revised; Communication and Reflection can be added to every phase).

In conclusion, the pathways described above can form different inquiry cycles. It is also evident that inquiry-based learning can be seen as cyclical on multiple levels. The actions taken in the *Conceptualization* phase determine the pathway in the *Investigation* phase. First interpretation of the data follows data collection. If there are enough data to confirm the hypothesis or to answer the stated question(s), moving forward to the *Conclusion* phase is expected. If the data are not sufficient or disconfirming, going back to the *Conceptualization* phase to review existing questions or hypotheses or define new ones is necessary. Moving back to the research plan or experiment design without changing research questions or hypotheses may be the

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[1] Pedaste et al, 2015, p. 56

solution if issues are identified in *Exploration* or *Experimentation*. Going back to Conceptualization phase may also be in response to new ideas that arise out of the collected data during interpretation.

In all phases from Orientation to Conclusion, the critical reflection and Discussion might be needed. Reflection can be viewed as on-going processes: results of reflection are used to review the activities specific to different phases or as an input for a new inquiry cycle. Similarly, Communication is seen as an on-going process: 'in-action' communication is part of an inquiry phase or 'on-action' communication is a separate activity at the end of the inquiry cycle.

How teachers can maximize the effectiveness of inquiry-based learning

Inquiry moves away from a purely teacher- or student-centred approach to a form of meaningful, sophisticated, and powerful learning where students and teachers work and learn from experts posing guiding questions, problems, or tasks that professionals in the field would recognize as important.

Inquiry-based projects that lead to deep understanding are supported by scaffolding activities, frequent opportunities for formative assessment, as well as powerful guiding questions (Darling-Hammond, 2008). Excluding elements of a task which are beyond the learners' capability, helping them to focus on and complete only those elements that are within their range of competence make an effective scaffolding (Simons and Klein, 2006).

A large body of research concludes that formative assessment is an extremely effective educational intervention (Bransford, Brown, & Cocking, 2000; Darling-Hammond, 2008; Hattie, 2009; Heritage, 2010). Feedback is most effective "when it is focused on the task and provides the student with suggestions, hints, or cues, rather than offered in the form of praise or comments about performance" (Heritage, 2010, p. 5).

Part B: Interactive methodological approaches in teaching science

Why multimedia approach

Multiple positive effects of technology on students learning are shown in a large number of studies. Technology implementation involves changes to the design and delivery of learning experiences and consequently, a change in teaching approaches, but also in the assessment process. Teachers are facilitators as they engage students in a more self-directed learning process that increases their motivation and self-esteem, facilitates deep learning approaches and development of competencies as integrated psychological constructs/learning outcomes. The accomplishment of more complex tasks, more collaboration with peers seems to contribute more to preparing young people for the shifting economic, technological, and socio-political realities of the 21st century. From the psychological point of view, according to the Allan Paivio`s theory of dual-coding interacting with content in multiple formats not only enhances motivation, but also retention, and transfer of learning outcomes. The value of text combined with images rises incrementally when the educational resource includes videos – moving images, which can unfold the transformations in a certain phenomena, or when the resource incorporates some interactivity with the respective content, may even signal ongoingly possible misconceptions or errors in the learner`s mind.

Educational resources in multimedia format consists of a blend of text, audio, animation, video, still images that could include interactivity content forms encouraging students to construct knowledge, express their knowledge in multiple ways, think critically and solve problems. Teachers can involve a wide range of activities to provide meaningful learning experiences using advanced media, devices and techniques.

Why Gamified learning

Games can be considered an illustration of constructivism application promoting the development of higher-order thinking skills which are hard to stimulate under traditional learning and resistant to a standardized assessment. Upton (2015) restates that "Games are a particular manifestation of play, not its totality. They happen to be a good starting point for an investigation of play because the formality of their rules makes the machinery of play easier to observe and analyse".

With games, motivation for learning increases as concepts from real world and fundamental relationships between them are discovered. Students develop skills for life regardless of age or level of development. Therefore, the chance for obtaining desired learning outcomes increases and a lot of attention is given to building games and simulations and developing theories about the use of game principles in education. Whitton (2014) proposes a review regarding the role of digital games in education. His discussion focus on games as active learning environments, games as motivational tools, games as playgrounds, games as learning technologies taking into consideration the relationship between gaming and learning. Initial and continuous professional development integrated in recent years more and more active methods into the current classroom activity and more educators are able to apply active and non-formal learning methods and integrate them with the subject matter competencies in a pertinent way.

Gamification is defined as "the use of game elements in non-game contexts" (Deterding, Khaled, Nacke, and Dixon, 2011). User purposeful and meaningful engagement in solving problems is rewarded, increases motivation and leads to learning achievement which can be measured. Due to its potential seems to be perceived as a constructive force in education as it involves creativity, critical thinking, collaboration and communication.

Why mobile learning

Today's generation uses digital devices, internet applications and/or social media on a daily basis.

O'Malley et al. (2003) have defined ***mobile learning*** as taking place when the learner is not at a fixed, predetermined location, or when the learner "takes advantage of the learning opportunities offered by mobile technologies".

Students' smartphones can be used for collecting experimental data as this technology offers students and teachers alike many chances on inquiry-based learning. (https://www.science-on-stage.eu/page/display/5/28/1290/istage-2-smartphones-in-science-teaching)

The phone can be turned into a pocket science laboratory by using tools to measure light, motion, sound and more. Projects are documented through notes, photos, and phone's built-in sensors. The ideas and observations are recorded using Science Journal app while the investigation generated to solve a problem is conducted. (https://sciencejournal.withgoogle.com/)

Why computational thinking

A renewed interest in many countries to introduce ***computational thinking*** as a set of problem-solving skills to be acquired is observed. Computational thinking is applicable to topics in science and mathematics staying at the core of Science, Technology, Engineering, & Mathematics (STEM) disciplines (Henderson, Cortina, & Wing, 2007; Weintrop et al., 2016) and providing the context for working with abstract datasets (Wing 2008).

Students solve problems reasoning abstractly and automating procedures through algorithmic thinking (Basu et al. 2014, Grover & Pea 2013). Algorithms-step by step approach to reach a solution comprises breaking problems into small units and recognizing patterns used in problems which were already solved successfully in the past. (https://code.org/curriculum/unplugged)

Using robotics and game design rely on abstraction skills, logical thinking, use of algorithms, and analysing and implementing solutions (Leonard et al. 2016) which results in authentic learning. Psycharis & Kallia (2017) also show improvements in students' reasoning skills in their research focused on teaching computational thinking in conjunction with computer programming.

Why virtual labs

In face-to-face teaching, risky experiments or exploration of inaccessible environments, lack of space and funding needed to provide materials for each student lead to viewing-only experience which is not satisfactory from the science processes perspective as this approach does not allow for a full student engagement. It is well recognized as a common practice. Therefore, an innovative solution to support teaching/learning science without compromising quality appears to be ***virtual science labs*** that replace successfully typical lab experiences.

More and more technology is brought into teaching and learning as online learning takes place all over the world. Consequently, virtual science labs are not anymore the way of the future, they are already the way for the present time. The current teaching methodology is supported by the proper preparation and structure of virtual labs. How virtual labs are integrated into teaching and learning of science can be followed here https://www.theedadvocate.org/13-must-virtual-science-lab-apps-tools-resources/

List of Open resources

Teachers could use the following resources developed at the European level in planning their activity.

1. Guidebooks for teachers, lesson scenarios etc. for students aged 6-18 from the project "Motivate and Attract Students to Science Education": http://mass4education.eu

2. 13 open access teaching modules on intercultural learning to prepare our future teachers for a timely science and mathematics education: https://inclusme-project.eu/

3. STEM Clubs are out-of-timetable sessions that provide young people with the chance to explore aspects of STEM (Science, Technology, Engineering & Mathematics) in less formal settings: https://www.stem.org.uk/stem-clubs

4. A collection of topic guides that can be used to stimulate debate of contemporary issues in the classroom: https://www.stem.org.uk/resources/collection/3337/debating-matters

5. Bringing Cutting Edge Science into the Classroom https://www.stem.org.uk/elibrary/collection/4017

6. STEM Alliance practices repository: http://www.stemalliance.eu/

7. The journal of stories in science: https://www.labxchange.org/

8. Articles about real scientists who are working in national research projects: https://futurumcareers.com/

9. Activity sheets and education / career resources suitable for secondary (or high school) and college students (11-19 years): https://futurumcareers.com/

10. mSTEAM collections that help students think like scientists, mathematicians or engineers: https://msteam.mschools.com/

11. Educational resources about the bioeconomy and bio-based products: http://www.allthings.bio/educational-resources/

12. The BLOOM School Box- collection of bioeconomy related teaching resources: https://bloom-bioeconomy.eu/schoolnetwork/schoolbox/

13. Schools as innovative ecosystems that act as shared sites of science learning in which leaders, teachers, students and the local community cooperate: https://portal.opendiscoveryspace.eu/

14. INSTEAM network which brought together the experience and learning of a wide range of projects in European Science and Mathematics education https://www.instem.tibs.at/node/21

15. Inquiry-based activities: http://www.arkofinquiry.eu/

16. Science teaching materials IBSE focussed: http://icaseonline.net/profiles

17. Education on energy, climate change and sustainability issues support: http://www.schools-at-university.eu/

18. European Journal for science teachers: https://www.scienceinschool.org/

19. Teaching materials developed from European STEM teachers for STEM teachers: https://www.science-on-stage.eu/

20. Set of science teaching/learning materials on city climate - Urban Heat Island campaign from GLOBE Program https://www.globe.gov/web/surface-temperature-field-campaign

Part C: Opening schools to local know-how

How to promote an open school approach?

An open school is characterized by the use of unconventional teaching methodologies, and Information and Communication Technologies (ICTs) to bridge the physical separation and provide education and training programs (Abrioux 2009). Open schooling (OS) is a flexible education mechanism that allows learners to learn *where* and *when* they want, often (but not always) physically away from a school and a teacher. It uses several teaching methods to support learning, and has no age restrictions, content of courses to be taken or number of courses in which students must enrol. At the same time, an open school is an organisation interested in removing barriers and allowing the local community (parents, representatives of local authorities, civil society and business sector, etc.) to interact and contribute to the learning processes and learning outcomes of the students.

In this sense the school needs to deliberately nurture 'an open school culture' in which there is a constant mutual exchange with the community, where on the one hand, external challenging ideas are integrated in the learning practice and addressed by the students' projects and, on the other hand, the school will directly impact on the community. Key element of such a culture include learner independence and interdependence which are developed through 'collaboration, mentoring, and through providing opportunities for learners to understand and interrogate their place in the world' (Sotiriou, S., Cherouvis. S., 2017). Such a culture involves an accurate acknowledgement of the actual resources available in the community, entertaining good relations with the relevant stakeholders (local authorities, private and non-private organisations, NGOs, parents) and actually starting an ongoing meaningful collaboration in a win-win situation with all these.

Connecting the school with the environment has a special significance for all school actors and all areas of learning, as it creates the necessary links between formal and non-formal curriculum, between national and local relevance of the curriculum (solving local community problems, creating the links between local community representatives). It empowers students to think as involved citizens, with a role in the well-being of their neighbourhood, and provides other citizens with concrete examples on the role of the school in community development (Johansdottir, 2017).

Learner-centeredness, lifelong learning, flexibility of learning provision, removal of barriers to access learning, recognition of prior learning, provision of sound learner support, construction of learning programmes in the expectation that learners can succeed (creating motivation), and maintenance of rigorous quality assurance over the design of learning materials and support system are the ideals on which open schooling is founded (Abrioux, 2009).

According to The Commonwealth of Learning – COL (p. 21)[2], "Open Schooling is not called open/distance schooling for a reason; that is Open Schooling may follow different patterns, but ***the most common scenario is that the learners study specifically designed open learning materials on their own at home, in their workplace, wherever it is convenient for them and then they meet together with a facilitator on a regular basis***".

The "open" in Open Schooling is a reference to the **open nature of the system**, removing various barriers in learning:

- youth that missed out on schooling in their childhood can enrol in courses which will provide them with the equivalence of secondary education without embarrassment of being in classrooms with children much younger than themselves;
- young mothers can take secondary-level education through studying at home, and attending tutorials only when necessary and their responsibilities permit;
- working adults can enrol in one or two courses at a time, and study whenever their personal and work commitments permit;
- young adults can acquire skill training coupled with academic subjects while self-employed or working as non-skilled labour. (COL, p. 21)

Moreover, The Commonwealth of Learning adopts the concept "Open Schooling" rather than "Open and Distance Learning" because **openness** and **flexibility** play a greater significance than physical separation. In the case of open schooling, face-to-face sessions with the facilitator are primarily designed to clear up any difficulties that the students may have experienced when working through the learning materials. As these face-to-face sessions are only rarely mandatory, the student is not affected if he or she has to "drop out" for a period of time since they can pick up their studies once again, when it is advantageous to them to do so.

Principles of Open Schooling

According to COL, "usually there are no rules dictating student ages, prerequisites, content of courses or numbers of courses in which learners must enrol. As a result, open schooling meets the needs of a broad range of learners" (Commonwealth of Learning, 2008). Specifically, open schooling can assist in dramatically improving access to high quality secondary schooling both by school-age children and by adults, just as Open and Distance Learning (ODL) has already done at the tertiary level for secondary school leavers and adults. By the start of this millennium (and in contrast to

[2] http://www.cedol.org/wp-content/uploads/2012/02/19-22-2007.pdf

the situation in primary education), there were sufficient examples of successful secondary OS both in the developing and the developed world.

The key principles of Open Schooling include the following (Abrioux, 2009):

- **Lifelong learning:** Learning is a lifelong process and should directly relate to the life experiences of the individual. For this to happen, the individual has to appreciate the relevance of what is learned and the motivation to learn is intrinsic.
- **Flexible learning:** Learners choose what they want to learn, how they want to learn and when they want to learn. The central pedagogical elements of open learning allow for individual differences and individual learning styles and learning preferences, unlike formal systems of learning.
- **Learner support:** Learners should be provided with adequate support to help them achieve academic success. Whilst studying is a personalized experience, support structures and systems should be in place for learners to fall back on whenever they experience difficulties.
- **Cost-effectiveness:** Open schooling systems should be cost-effective but should not compromise on the quality of the education they provide.

Although there is overlap between Open Schooling and Distance Education, the two terms can be compared based on the above-mentioned principles. Specifically, Distance Education refers to a set of practices to plan and implement educational activities where there is a separation between teaching and learning, and this separation may result from distance, time, or other barriers. Distance education offers a way to overcome this separation, chiefly through its learning materials, the use of information and communication technologies to provide tutoring, linking learners to the system and each other, and the use of feedback and student support systems (Murphy, Anzalone, Bosch & Moulton, 2002).

Beyond differences, Open Schooling and Open Distance Learning have convergent approaches to the learning process:

- the learning is intentional and well-planned;
- the study pattern is flexible and student controlled;
- unconventional teaching methods, Information, and Communication Technology (ICT) are used for correspondence.

In addition, OS puts an important emphasis on creating a learning path widely adapted to the needs of a broad range of learners, not sticking to the rules dictating specific prerequisites, fixed pace and detailed learning outcomes of courses in which learners must enrol.

Many initiatives (e.g. Extended Schools initiative proposed by the DfES[3]) support schools that provide services and activities beyond the school day, to help meet the needs of the students, their families and the wider community.

Craig et al. argue that ”to work successfully, extended schools have to become open institutions, alive and responsive to priorities, cultures and resources that lie beyond the school gate.” (2004, p.5). The idea behind extended schools is that teachers, parents and professionals work together as co-workers. The extended school facility encourages parents and local people to become involved in their children’s education and offers them the opportunity to enrol on adult education courses themselves. The Extended Schools initiative offers different services from childcare to ICT access. Recent reviews of the literature on extended schools note the diversity of provision (Wilkins et al, 2003; Cummings et al, 2003), although Wilkins et al. comment that British initiatives tend to be more educationally focused while American projects emphasise the socio-economic aspect (p.3). The recent evaluation of Cummings et al. concludes that extended schools “impacted on pupils, families and communities in a range of ways and generated positive outcomes for these groups’, but warns that such projects need good management, resources and planning. Additionally, this report suggests extended schools seem likely to interact with other initiatives, and this could “bring about a series of changes and ultimately generate …ambitious outcomes”. (p.v).

Teaching and implementing models

To a large extent, the teaching model in the OL has a different approach from teaching in the traditional education model, as it requires providing students with a particular learning context (Schocroft, 2009):

• adequate student/teacher interaction for effective learning;

• feedback in a timely, useful manner;

• just-in-time learning support;

• access to practical facilities such as laboratories;

• supervision to ensure safety and welfare of students working remotely on machinery;

• examination practise and supervision.

[3] The Department for Education and Skills (DfES) was a United Kingdom government department between 2001 and 2007. The department was responsible for the education system (including higher education and adult learning) as well as children's services in England.

Most of the times, Open Schooling is offered at the secondary level to students/learners who have achieved a basic level of literacy. Given the flexible format of OS, there are exceptions, such as the Interactive Radio Instruction (IRI) initiative in Zambia (Commonwealth Education Partnerships 2007). In this case, in addition to providing literacy education for children in grades 1-4 under the guidance of a mentor, the programme is also attracting adults who did not have the possibility to attend classes when they were young. People ranging in age from 17 to 51 are enrolled in classes and are following the same syllabus as the children, which provides a Second Chance approach.

All in all, there is a dire need for more research, as well as for the examination and exploration of new models aiming at expanding Open Schooling at other levels of education or other learning paths. Documenting these initiatives can help the educators and decision-makers to understand the conditions to scale them up with full confidence.

Nevertheless, with the help of additional capabilities for delivery and support offered through newly available and affordable ICT, the potential for the use of Open Schooling has recently become increasingly important. Moreover, primary and secondary schools started to combine formal with non-formal and informal approaches in competence development, following the principles of open schooling, in particular learner support and cost-effectiveness. The programs are designed for various purposes, such as:

- offering ***additional learning contexts*** to students aiming at developing specific competences, expanding their knowledge of a specific subject
- creating ***multi-, pluri- or inter-disciplinary approaches*** in teaching a specific subject
- creating ***new learning opportunities*** for students at risk, with a low family support in learning
- creating ***remedial education programs*** for underachieving students.

Inclusion of stakeholder groups – educators, parents, students, teachers – encourages acceptance and ownership of OS as a viable part of education as an organisation that includes stakeholders in the process of determining needs and interests will be better aligned to context.

Challenges of OS

Specific aspects that need to be particularly taken into account in all OS initiatives:

i) while students are encouraged to establish a dedicated learning environment, they are in a wide range of living and working arrangements and variability occurs;

ii) more people are involved in the process of providing education: school coordinators, test supervisors, tutors and others and this may cause variations in quality of service and

iii) communication with students and parents is variable, as students can more easily vanish from the ODL system without the school intervening in an effective manner.

It is also necessary to pay attention to the recognition by key stakeholders of the quality of materials and overall quality of the teaching process. The role of the teacher is changing and this will require support, both through professional learning and opportunities to work in teams, to share and to learn together.

At the same time, the geographical spread of students and the social isolation of many make the development of partnerships difficult and yet imperative. Policies and structures are required to enable and support these alliances.

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