Case Study 7: Project-based science learning in the school garden, seen as an open and collaborative environment for all

Nektarios Tsagliotis
9th Primary School of Rethymno, Crete, Greece &
@ The Primary Science Laboratory (PSL) [efepereth@gmail.com]

"To maintain the state of doubt and to carry on systematic and protracted inquiry – these are the essentials of thinking", Dewey, 1910/1997, p. 13.

There are two sections in this case study:

A. The Case Study
B. Deconstructing this case study

Section A. The Case Study

Nektarios is a science teacher-researcher and at the 9th Primary School of Rethymno, Crete, Greece for the past 20 years or so. He is also responsible for the "Primary Science Laboratory" [PSL] and the "organic school garden" for the last 16 years and also the vice head-teacher of the school for several years.

Background

The 9th Primary School is a state/public school, which was established in 1985 in Rethymno, Crete. It is located in the suburb of Missiria, on the outskirts of the coastal town of Rethymno. The student population of the school is aged 6 to 12 and has a mixed socioeconomic background. Most pupils are of Greek origin, however, in the past few years, due to political changes that have affected east Mediterranean countries, a great inflow of immigrants and refugees were welcomed in our school. Today there are 250 pupils enrolled and 30 teachers, most of which are permanent staff and have been working in the school for years.

A consistent effort has been made to upgrade the school standards in terms of infrastructure and quality of teaching over the years. The **"Primary Science Laboratory"** (PSL), which has been established and incorporated at the school premises since 2005, aims to assist and support the teaching and learning of science, but also provides in-service teacher training, as well as research and development in the creation of educational content. Indicatively, three thematic "science fairs" have been organized by the PSL, which had a successful impact to the educational and local community. Also, a series of 3 consecutive "School Environmental Education Projects" has been conducted, which were co-financed by the E.U., within a framework of an open school to society, raising public awareness on scientific, environmental and ecological issues. The research work of the PSL has a strong presence and impact nationally and internationally for over 16 years through the participation and active involvement in several EU Projects (FP6, FP7, e-Content+, Horizon 2020, as well as Comenius 1 and Comenius 3 Networks & Erasmus+).

An "**organic school garden**" has been developed since 2005, where pupils get the chance to cultivate and grow crops "from seed to seed", learn about healthy eating, and share their produce with the local community, together with the "Cretan Kings Basketball Club" [2015-2019], within a framework of volunteerism, solidarity and active citizenship. The "prototype nature" of this school garden has led the PSL and the school to co-organize 3 national educational scenario contests**,** with the title: *"School gardens: production and disposal of agricultural products"*, under the auspices of the Institute of Educational Policy and the Ministry of Education, with the support of EU Projects such as "Inspiring Science Education" [ISE], "GreeNET" & "Open Schools for Open Societies" [OSOS] (cf. Tsagliotis, 2015). In March 2019, the school garden and the PSL received an EU distinction of excellence within the framework of the OSOS Project (2017-2020) for the work on *"Companion Planting in the school garden"*, establishing plant partnerships in micro-ecosystems and "plant societies", much like collaborations in human communities.

Pedagogical Focus

A school garden, needless to say an organic school garden, offers a place to enrich teaching efforts with powerful hands-on activities and experiences that make learning come alive, ideas and concepts come into being, within a project-based learning focus as a whole. Developing a school garden is not rocket science, neither a “build-it-and-it-will-come” endeavor, but rather a systematic exercise and collective work, which presents a certain level of complexity and must be “child-generated” in order to be “child-owned”. If children lack ownership, they will lack a sense of stewardship. Sustainability requires stewardship. If the garden is to be used, respected and cared for, then stewardship is the key. The foundation of success is not necessarily in proper construction or sound plant selection. Although these are important dimensions of successful organic gardening, it appears that it is not so much the garden, but rather the "garden programme" and the integrated activities that matter and make the difference, raise the educational added value, often harmonically incorporated in the (national) curriculum. Successful (organic) school gardens are built on the foundation of committed people, bearing in mind that although *“there might not be a garden in every school, but there is definitely a school in every garden”,* my favorite motto over the years.

Thus, it is claimed that “Garden-based Learning” [GBL] can be viewed and organized as "Project-based Learning " [PBL] for pupils, within a broader context of “Inquiry-based Science Education” [IBSE]. This means that it cannot be defined simply as a set of instructional strategies that utilize a garden as a teaching and learning tool/environment, but moreover it is the creative and purposeful synthesis of the parts that can make the meaningful difference for the learners. The pedagogy is broadly based on experiential education, which is practiced and applied in the living laboratory of the garden. Moreover, GBL as PBL has the potential to enrich basic education in all cultural settings. In cases where it is most effective, GBL is a pedagogy that is used with all children. It has something to contribute to each learning style and to all children at each developmental level (Christopher, 2019).

Garden-based learning can offer a context for integrated learning, within and across the curriculum subjects. Such an integrated proposal for the curriculum is often associated with real-life problems and project-based science learning, in contrast to a traditional subject-based curriculum. This provides a vehicle for higher order thinking skills as pupils are challenged to move beyond memorization, to see patterns and relationships and pursue a topic in depth, within a thematic/holistic approach (Christopher, 2019). They are engaged in actively and socially constructing and construing knowledge, rather than passively accumulating and accepting information and they also develop analytic and synthetic thinking. At the practical level, developing GBL and PBL skills raises the importance of (organic) gardening practice, through which pupils gain firsthand experience with the seed-to-seed cycle, the rhythm and traditions of the harvest, and the taste, touch, and smell of fruits, vegetables, and flowers (Danks, 2010). Proponents of children’s garden programs talk of the multiple developmental benefits that school gardens can have on children namely, emotional, aesthetic, and even spiritual in addition to the more obvious social and intellectual benefits, in a variety of contexts (Thorp, 2006).

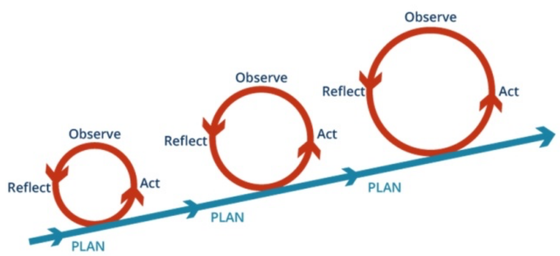
Research Question

There is a major educational reform under development in Greece over the last 2 years, which involves the change of national curricula for all subjects taught in primary and secondary schools, including science. The new curricula are to be published in October 2021, accompanied by educators' guidelines and in-service teacher training scheme, for the coming two years or so. The challenge for the research work and experience which has been accumulated at the Primary Science Laboratory, concerning the Garden-based learning within the framework of Project-based learning, is to further investigate the integration and harmonization of the conducted research within the framework of the new curricula.

Thus, (a) research question(s) can be formulated as the following:

- Can project-based science learning, already conducted in the school garden, match the changes/challenges of the new curriculum subjects?
- Which pieces of research and development in educational content can be adapted, reconstructed and/or further elaborated, within the school community and in a framework of open schooling?
- What kind of new content ideas can be developed within the open and authentic learning environment of the school garden?

Cycles of Action and Data Collection



John Dewey, about a century ago, referred to the "teacher as investigator", recording his personal view as follows: *"it seems to me that the contributions that might come from classroom teachers are a comparatively neglected field; or, to change the metaphor, an almost unworked mine"* (1929, p. 46). Over the last century, this "unworked mine" appears to have been "excavated" to a certain extent, (re)forming the characteristics of systematic "practitioner research", setting the active agents on stage, characterized as "teacher-researchers" and creators of "professional knowledge". *Lawrence Stenhouse* (1975) defines teacher research as *"a self-reflexive process that is systematic, critical inquiry made public"*. Additionally, his famous quotation has been *"It is teachers who, in the end, will change the world of the school by understanding it"* (Stenhouse, 1981), which involves: a) the commitment to systematic questioning of one's own teaching as a basis for development, b) the commitment and the skills to study one's own teaching and c) the concern to question and to test theory in practice.

Indicative features of "teacher-researchers" are the following:

- Teacher-researchers have an insider, or emic perspective
- They mix theory and practice (praxis) while teaching and researching within their classroom worlds

- Teacher research is pragmatic and goal oriented
- There are practical classroom problems that need to be tackled and solved
- Teacher research involves disciplined inquiry, which means that studies are intentional and systematically conducted

A few basic characteristics of "practitioner research" can be recorded as follows:

- It is conducted by an individual or group that assumes a dual role, both as a practitioner or provider of services and as researcher
- It is typically carried out for the purpose of advancing the practice
- It offers a reflective and systematic approach to research and outreach, as it places a study setting and participants at the heart of the inquiry within a recursive process
- It incorporates the collective knowledge of the community, and increases the likelihood that results will be applied
- The methods may vary, but the role and relationships of the researcher and participants must be carefully negotiated and articulated

Thus, practitioner research is intentional and systematic inquiry conducted by teachers with the goals of gaining insights into teaching and learning, becoming more reflective practitioners, effecting changes in the classroom or school, and improving the lives of pupils (Cochran-Smith & Lytle 1993; 1999). Following the distinction commonly made in the field of education, Cochran-Smith & Lytle (1993, 1999, 2009) group four types of teacher research into two broad categories: *empirical* and *conceptual* (cf. analytic framework below, with data collection methods and/or techniques for each of the 4 types of teacher/practitioner research).

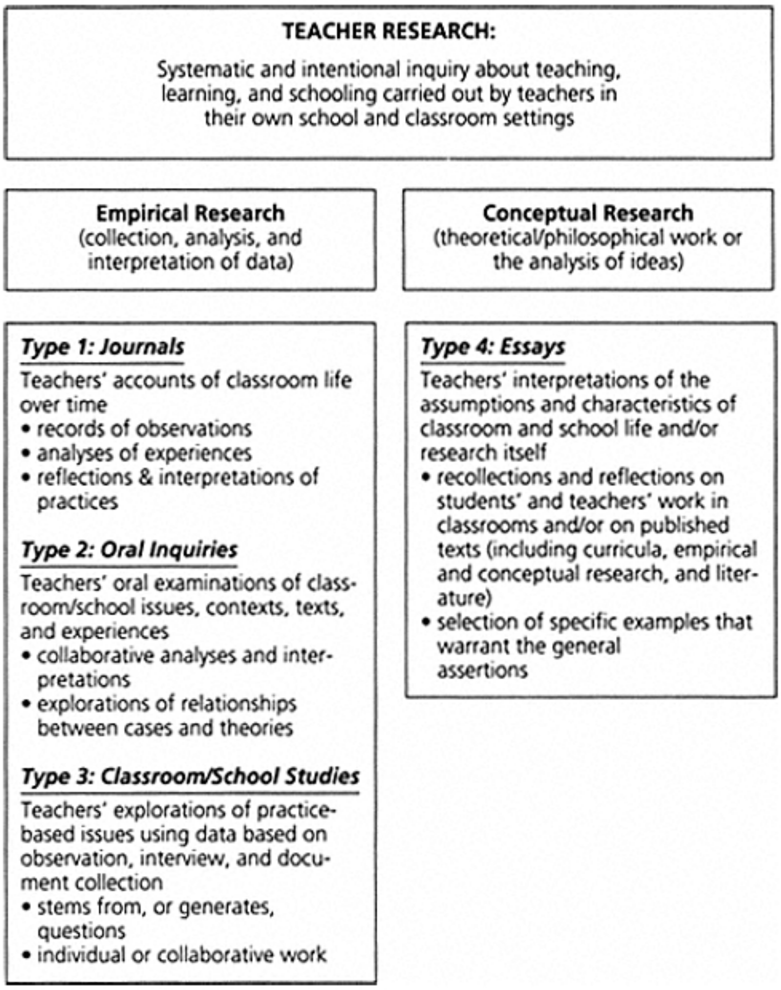


Fig 1: Teacher/Practitioner Research: An Analytic Framework, Cochran-Smith & Lytle 1993, p. 27 & 2009.

Practitioner research has often been closely associated with what is called evidence-based practice, in that it has served as a strategy for trying to ensure that teachers introduce practices validated by research into their classrooms. In consequence, teacher-researchers conduct systematic research supported by evidence collected within the framework of their active involvement into practice, seen as "evidenced-based practice". Nevertheless, I agree with Dana (2016) that in contrast to evidenced-base practice, "practice-based evidence" should be more frequently identified and defined as *"the many forms of data that are naturally generated from the everyday teaching and learning acts that take place in classrooms and schools"* (ibid.). These data when discerned, closely, carefully, and critically over time, become the evidence teachers use to make informed instructional decisions and adjust these decisions on a regular basis. Thus, "practice-based evidence" is generated through the process of practitioner research, which is quite different in purpose and nature than the "experimental research" generated mainly by university institutions, which mostly leads to the determination of evidence-based practices, often identified as such. Contrary to the types of research done to determine evidenced-based practices, practitioner research does not (only) focus on control and prediction, but rather on *“providing insights into teaching in an effort to make change”* as teachers work *“tirelessly to unpack all of the complexities inherent in the act of teaching to become the very best teachers they can be for every individual student”* (Dana & Yendol-Hoppey, 2014, p. 9).

Within the aforementioned typology of practitioner research, the focus in this case is on "type 3: classroom/school studies" of *empirical research,* in combination with *conceptual research* of "type 4: essays" and elaborated publications. In order to illustrate this, I will briefly present two examples of recursive practitioner research with project-based learning in the school garden environment, which have been reoccurring, revised and extended over a period of ten years, at least.

Example 1:
"Microscope studies in the school garden following the footsteps of Robert Hooke in Micrographia"

This is a repeated project-based inquiry, usually conducted with 6th grade children (11-12 year-olds). Initially, each child constructs a simple reflective microscope using modern materials like a plastic tube and two plastic lenses (objective and eye piece), which were extracted out of single-use disposable cameras. It is actually a modified (re)construction of a microscope (approximate magnification 20x), which has been proposed by researchers of the *Istituto e Museo di Storia Della Scienza* of Florence (now, Galileo Museum). At a later phase, an extra middle lens has been added to the microscope to minimize distortion, create sharper images and enhance magnification by 3-5 times. Over the years, various types of microscopes have been used to conduct the studies and investigations, recently ones made out of paper, the famous *"foldscopes"*.

The children are briefly introduced to the historical development of the microscope, with a focus on the life and discoveries of *Robert Hooke* (1635-1703), from the early years at the Isle of White till the achievements of *Micrographia* (1665), having him portrayed as a natural philosopher and polymath who played an important role in the scientific revolution, through both experimental and theoretical work. After that, *microscope studies* are conducted with each child recording their observations with the constructed microscope (or any other type) on a notebook with text and sketches, in an approach inspired by Hooke’s Micrographia. Before putting down their notes on paper, they study a relevant extract from the classic text of Hooke, adequately transformed and adjusted for the instance. Thus, following similar steps to those of Hooke, the children initially study the point of a needle and a small printed dot, which have also worked as focus exercises for the use of the microscope. Then they study plant seeds (thyme and petunias) as well as parts of plants during their development in the greenhouse and the school garden. Later, they study garden insects, conducting “*insectigations”* as they call them, examining ants and isopods, for instance. They usually conclude with a free study, on either plants or insects, since, by that time, they usually develop interests in various and diverse specimens found in the school garden and they want to examine further. The children discuss and exchange in class their notes and observations, within a framework of investigations about the development and functions of plants and insects. The analysis of children’s notebooks reveals aspects of “doing science” in a project-based learning mode, within an authentic environment (inquiry-based teaching and learning), creating a framework of young learners’ scientific community dealing with an intentional task and/or investigative activity (cf. Tsagliotis, 2010; Seroglou *et al.*, 2011; Tsagliotis 2012).

Example 2:
"Companion planting in the school garden"

This set of project-based learning activities is recursively approached, roughly twice a year, with pupils of all ages of the primary school, at the school garden. Its main purpose is to raise interest and sensitize pupils in organic agriculture through gardening practices and experience on cultivating plants organically, developing a viable cultivation culture through companion planting. In other words, incorporating viable agriculture practices and organic gardening in the classroom helps learners understand how humans interact with the environment and how food is grown. Further, agriculture and school gardening promotes awareness of a healthy lifestyle, helps students master even demanding science concepts, and exposes students to agricultural job opportunities. By designing, cultivating, and harvesting organic school gardens, children experience deeper understanding of natural systems, ecosystems or "plant societies" and become better stewards of the earth.

Nevertheless, unlike some other activities they participate in during their school years, gardening is an activity they can participate in for the rest of their lives. On a personal level, gardening builds confidence, self-esteem, and pride as children watch their efforts turn into beautiful and productive gardens. It also teaches them patience as they wait for a seedling to sprout or a tomato to ripen. Through gardening, children help to beautify the school grounds and develop aesthetic skills. The praise they receive from peers and classmates, parents, teachers, and community members will enhance responsibility, create a sense of community spirit and collaboration and inclusion, under the motto *"every plant is valuable, every plant contributes"*, just like in humans in communities and societies.

Thus, knowledge and practice is reported and shared, regarding companion planting, that is “planting together with benefits”. Under the standard cultivating year-round approach, working on "from seed to seed“ activities, pupils prepare the "seed plants" in the greenhouse, later to be transplanted to the garden raised beds in a companion planting mode, enhancing the benefits of companionship and biodiversity in action. Many different combinations have been tested in the garden raised beds over the last 12 years, as knowledge and practice is also passed on to younger by older classmates and community members and it has been found out that some combinations can actually help one or more of the companions flourish. The vegetable crops are getting better and pupils are happy to have more quality products to share within the community (cf. Melissourgou *et al.*, 2019).

Data Analysis

In the ***microscope studies*** in the school garden, children's written observations and drawings are generated in the classroom/laboratory and analysed in multiple ways. For instance, the investigation on insects, is an *"insectigation"* in a creative term (Blobaum, 2005). Hooke had conducted several studies of insects in *Micrographia*, but one of his most descriptive and at the same time more familiar to primary school children is the one on the *ant*. He mentions that he had a hard time trying to keep the ant steady under the microscope for observation. Having selected some ants he *"made choice of the tallest grown among them, and separating it from the rest, gave it a Gill of Brandy, or Spirit of Wine, which after a while knocked him down dead drunk, so that he became moveless, though at first putting in he struggled for a pretty while very much, till at last, certain bubbles issuing out of its mouth, it ceased to move"*.

Then he was able to take the ant under the microscope and study it, although after an hour or so *"upon a sudden, as if it had been awaken out of a drunken sleep, it suddenly revived and ran away"*. He records that this could happen a few more times, so he could inspect the insect without killing it. The children found this whole process rather strange at first, but fascinating later on, since they had to deal with the exactly same problem in their study of the ant. So, they went out in the school garden "hunting for ants" to be kept in small plastic pots filled with alcohol lotion (see fig. 2). They observed that the ants were "unconscious" after 10 minutes in the alcohol lotion, ready to be put under the microscope for inspection. All of a sudden, most of them revived and started moving after 20 to 30 minutes or so. In this way, most of the children managed to observe the ants in a steady position, but also in motion and they were very thrilled to be able to do so (see Fig 2 & 3).

One child mentions in the written observation on paper, that *"the ant was very difficult for me to draw, since it did not easily stay in its position. When I took the ant out of the alcohol lotion it was asleep and I could observe it for a while and I started drawing it, but after 15 minutes it woke up and started moving again. The shape of its head is triangular and its eyes are sticking out. It has a big mouth with bumpy* *sawing teeth and it also has two long horns in front. The biggest part of its body was its belly, which is connected to its legs with some sort of small waist. Over all, it is a very strange insect under the microscope and it surprised me when I saw it so big for first time”*

	
Fig. 2: Ants hunting in the school garden dropped in alcohol	**Fig. 3:** Ants under the microscope, photo & child's drawing

On the other hand, the efforts and explorations on ***companion planting*** have led children to create an effective cultivating practice and an increased crop production. The “community of plants” in the school garden, following biodiversity and companionship principles, has proved to be viable and fruitful. First, they start with the seeds, because seeds are important! They make seed plants in the greenhouse and wait for them to stem and become little "baby plants". That might take 2 to 4 weeks. Then, they take them to the raised beds and plant them together in groups, 3 to 5 different plants in each raised bed, and are arranged in rows depending on the size they get when they grow up. "Symbiotic relationships" are created in the school garden, since children carefully arrange the "planting buddies" together, in order to be in "good company". Children and plants have one common goal: to be friends and work together. They can all complete each, for the common benefit and prosperity.

Usually, they plant lettuce together with onions and radishes, as they have found out that these plants are good garden buddies and companions. They also get along with Swiss chard pretty well. They also plant onions with lettuce and tomatoes. Onions naturally keep away aphids and other pests. This means that good companion plants for onions are any plants that often fall victim to them. Children plant fast-growing, cool-weather crops like lettuce or radishes early in spring together with slower-growing, heat-loving tomatoes. Thus, they will be able to harvest our early lettuce and radishes quickly, making room for the tomatoes to take over their space later.

Children also conduct "fair tests" and companion planting explorations in the school garden. Hypothetically, they struggle to have as similar conditions as possible in two neighboring garden raised-beds: same size, same soil, same sunshine, same watering etc. In the first bed, they practice companion planting with: i.e. lettuce (romaine, green & red lollo), parsley and onions. But, in the second one they plant romaine lettuce alone. Early spring is a rather proper time in the year to conduct this exploration in the school garden. Fellow pupils have been doing explorations as such for the last decade or so and they have collected valuable knowledge and practice, which is passed on to younger children (cf. Fig. 4 & 5). They have repeatedly claimed that the lettuce plants cultivated with other companion plants have grown big and healthy, whereas when cultivated alone, they often get pests, grow smaller and are not very tasty, in fact they are a bit bitter. But, there still more explorations and tests to be planned and conducted again this year, in order to investigate if their claims, and those of the earlier class-mates, can be verified in reliable ways.

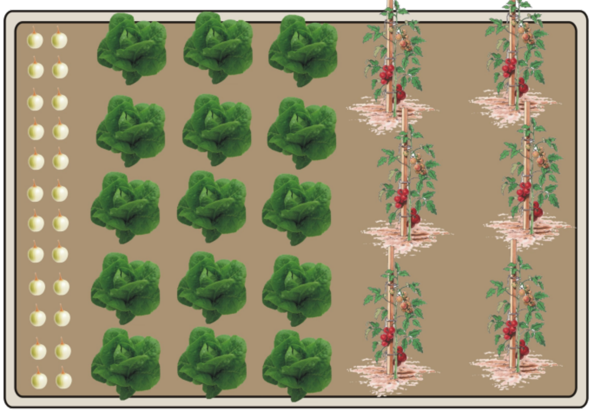


Fig. 4: Companion planting ideas & test plan put on paper.	**Fig. 5:** Companion planting in the school garden raised-beds.

Making Claims

It is generally claimed and thoroughly examined that such project-based learning activities, within the "garden-based learning environment" are highly beneficial to the pupils in many ways and harmonically integrated to curricula and syllabi of many kinds. They appear to have the basic characteristics of project-based science learning in action, actually a "science in the making" approach in authentic contexts, with enhanced familiarity, ownership and commitment to the framework of activities/investigations, and not only.

Conclusion

Microscope studies in the school garden

It appears that the children have been mentally and emotionally involved in their microscope studies and they have been led with interest into their investigations and observations. The microscope studies, as approached through the texts and drawings of Hooke, appear to enroll elements of intentionality with an increased interest for the outcome and the recorded observations. During the process of recording the observations and/or descriptions, it was noticed that they come about smoothly, whereas the framework of the activity seems to facilitate and enhance the text production and drawings.

The written descriptions produced seem to have an initial influence from those of Hooke, whereas they are simultaneously developed and enriched within a concurrent field of language and communication. The drawings, either simple or more complex and more descriptive, appear to be created by children with interest and commitment, because they claim that they want to work in a "scientific" way as Hooke has done. Even if some children complain that they cannot make "nice drawings", they get into the endeavor of "drawing something" and attempt to comment on it verbally.

It appears that the whole framework of these microscope studies has elements of authenticity and the children get into the process of *"doing science themselves"*. The character and nature of science is being demystified as it becomes an everyday activity dealing with an instrument, the microscope, constructed by children themselves with simple and common materials. Yet, it appears to introduce them "naturally" to a framework of scientific study and investigation.

Companion planting in the school garden

It seems that the "lore", the mystery and the science of companion planting have intrigued and fascinated people for centuries, yet it is a part of the gardening world that has not been sufficiently explored. Even today, we appear to be just on the threshold of research. In years to come it is anticipated that scientists, gardeners, and farmers everywhere will work together in making more discoveries that will prove of great value in augmenting the world's food supply. The school community has claimed that citizens' science and knowledge can help in that direction, as well.

Thus, children have decided to continue to test our ideas through applications and explorations in the school garden, in order to contribute and "add their little bit" of project-based research in the aforementioned framework..
Plants that assist each other to grow well, plants that repel insects, even plants that repel other plants, all are of great practical use. They always have been, but children feel that they are just beginning to find out why. Delving deeply into this fascinating aspect of gardening and companion planting can provide the school community with both pleasure and very useful knowledge to develop and share.

For example, from their research investigations so far, children have noticed repeatedly, that broccoli are good garden buddies with lettuce, onions, spinach, dill and Swiss chard, whereas they also appear to benefit from the oregano and thyme plants, which are located around the school garden. Tomatoes, on the other hand, are not good garden buddies with broccoli, cauliflower, dill and corn, whereas they are good companions with lettuce, beans, onions, garlic, parsley, peppers, as well as with marigolds and basil (their "bodyguard"). As for the carrots, children have strong indications that when cultivated near tomatoes, they *"will have good flavour, but stunted roots"*. Well, seen from a different angle, children have insisted in cultivating tomatoes and carrots together in a rich soil, with plenty of the compost mixture produced in the school garden, from organic matter and plants leftover. The carrots grow big and tasty and tomatoes are aromatic and rather sweet. Thus, they tend to conclude that perhaps it is "the soil factor" that makes a difference or maybe the local climate conditions of the Northern part of Crete, or even the "plants community" children have created in the school garden. It is a common agreement and a generated belief that further investigation is needed, in well documented repeated and recursive growth cycles, for knowledge claims to pass on from class to class, within the school community.

Section B. Deconstructing this case study

Background

Practitioner research in education takes many forms and serves a range of purposes, but it is conducted by teachers, individually or collaboratively, with the primary aim of *understanding teaching and learning in context and from the perspectives of those who live and interact daily in the classroom.* Because the word *research* is often associated with the use of rigorous scientific methods, the term *inquiry* has often been preferred in the report documents, not that the latter lucks in systematicity and congruity. However, the distinction between teacher/practitioner research and conventional outsider research about teaching is less about methodology and more about the very nature of educational practice.

According to Dewey (1933/1985), education is best practiced as "inquiry", and teacher/practitioner research employs the “scientific approach” to inquiry. While some teachers regard inquiry as a natural part of their everyday work in the classroom, others also collaborate with university researchers while teaching full time in their classroom or school, contributing valuable insights to the questions under investigation. Whether reflecting on experiences in the classroom or systematically studying an issue, as it happens in the framework of this case, teachers are often in the best position to ask and answer questions about children and learning, i.e. project-based learning.

Children are at the forefront of teacher/practitioner research. The studies are usually designed to help teachers gain new ways of seeing children, develop deeper understandings of children's ideas, conceptual knowledge, feelings and growth etc., and become more responsive to children.

Children's voices are heard through their own words and gestures, photos, texts, diaries, drawings, portfolios, and any other ways by which they are best portrayed. As teachers begin to observe closely, they see children's development played out in their own unique classroom contexts, always influenced by the potentially overlapping cultures of home and school lives. Unlike with conventional educational research, children and families are not *just* the subjects of research; they are participants and often co-researchers in the whole process. In this way, teacher/practitioner research is participatory, inclusive of differences and democratic in nature.

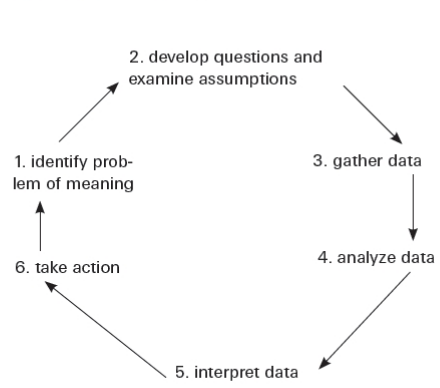
Pedagogical Focus

"Doing Projects" and "Project-Based Learning" are not quite the same thing. "Projects" can represent a range of tasks that can be done at home or in the classroom by groups of students, quickly or over time. While project-based learning (PBL) also features projects, in PBL the focus is more on the process of learning and learner-peer-content interaction than the end-product itself alone. The learning process is also personalized in an authentic and progressive PBL environment by children as learners asking important guiding questions, and making changes to products, ideas, investigations etc. based on individual and collective response to those questions (Krajcik & Czerniak, 2018).

In PBL, the projects only serve as an infrastructure to allow children to play, experiment, use simulations and/or on site learning (i.e. microscope studies in the school garden), address authentic issues, and work with relevant peers and community members in pursuit of knowledge. By design, PBL is learner-centered and open-ended. Students don't simply choose between two highly academic projects to complete and submit by a given date, but instead use the teacher's experience to design and iterate products and projects that often address issues or challenges that are important to them and to the school community as a whole (i.e. companion planting in the school garden).

Research Question

The Cycle of Inquiry



Research question(s) are important and characteristic of the study/case itself, but let us take a more detailed look at the teacher/practitioner research process, as a recursive and reflective "cycle of inquiry" (see fig. aside). After defining the problem or interest, a teacher may draw upon a combination of theory and intuition, experience and knowledge of children, observation and reflection, and perhaps the experiences of valued colleagues to develop relevant questions and assumptions (hypotheses). These questions develop gradually after careful observation and deliberation about why certain things happen in the classroom and particular issues arise (i.e. project-based science learning and the new national curriculum). Questions are not usually formed with the goal of "quick-fix solutions", but rather involve the desire to understand teaching and/or children's learning in systematic ways. Information (data) is collected through multiple means, which might include doing formal, informal and participatory observation, conducting interviews, collecting artifacts and portfolio items, or keeping a journal, to name but a few. Assumptions may be reformed or reconstructed by gathering, analyzing and interpreting evidence, "practice-based evidence", as it has already been mentioned above.

Ultimately, conclusions, findings and discoveries are used to further reflect on and address the original problem(s), and the cycle of inquiry continues as the teachers live out the process in the classroom on a daily base. This process, is often more messy and disorderly than may be implied here, especially in real classroom settings where practitioner research is conducted.

Thus, the first research question in this case is dependent to the new curricula which are to be published in October 2021, although it is claimed that the topics in the classroom studies (cf. the two examples) covered so far are of a multimodal nature and there is an increased likelihood they can be incorporated and/or adjusted accordingly.

- Can project-based science learning, already conducted in the school garden, match the changes/challenges of the new curriculum subjects?

The second question determines future/further cycles of practitioner research, based on conducted research and development in the classroom and the school garden.

- Which pieces of research and development in educational content can be adapted, reconstructed and/or further elaborated, within the school community and in a framework of open schooling?

The third question is open to new ideas and new developments over the current school year.

- What kind of new content ideas can be developed within the open and authentic learning environment of the school garden?

Data Collection

Data collection techniques, as previously described and shown, are children-based and authentic, as authenticity dependant validity of the data is a vital issue. They are mostly qualitative and they range from filed notes and diaries, to observations, children's written work and project work, as well as actual artifacts, from microscopes and specimen selections to garden beds testing arrangements and products.

Data Analysis

Data analysis is often qualitative and of thematic nature (Xu & Zammit, 2020) with groupings of conceptions, and/or pieces of texts and drawings, in an attempt to highlight, interpret and understand deeper insights of the data, within a "bottom-up" analysis and report of a "story", as filtered and inferred by the practitioner researcher's point of view and through peer review and judgment, whenever and wherever possible and applicable.

Making Claims

The claims referring to practitioner research are often context dependent, name it school, classroom, children and/or educational content etc. Thus, as claimed above, the two particular examples of this case appear to fulfil their framework of claims, which means there is "practice-based evidence" that "project-based learning", as conducted in the school garden environment, is authentic and of high educational added value for the children. Moreover, they appear to be creatively engaged in "science in the making" processes, developing practical skills, deeper knowledge and understanding, which most likely indicates a pathway for further research and development in the framework of the research questions previously described.

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