	REFERENCE	TEXT
1	Bruce & Casey (2012) The Practice of Inquiry: A Pedagogical 'Sweet Spot' for Digital Literacy? Computers in the Schools	As we think of pedagogies for a digital age, we have an opportunity to reconsider the basic models of teaching and learning. One starting point is the interests of the learner, as categorized by John Dewey: "the interest in conversation, communication; in inquiry, or finding out things; in making things, or construction; and in artistic expression." He called these "the natural resources, the uninvested capital, upon which depends the active growth of the child" (Dewey, 1956, pp. 47–48). Dewey stated similar ideas in a process form in his stages of reflective action (Dewey, 1910) and in his definition of inquiry. The latter uses the idea of situation to provide a descriptive account of how we survive in the world: "Inquiry is the controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole" (Dewey, 1991, p. 108). Inspired by these sources and the fundamental idea that learning begins with the curiosity of the learner, a spiral path of inquiry was envisioned: asking questions, investigating solutions, creating, discussing the discoveries and experiences, and reflecting on new-found knowledge, followed by asking new questions (Bruce & Bishop, 2002). Each step in this process naturally leads to the next: inspiring new questions, investigations, and opportunities for authentic "teachable" moments. Each question leads to an exploration, which in turn leads to more questions to investigate (Bruce & Davidson, 1996). Thus, reflection on solving a problem may lead to reformulating the problem or posing a new question. Similarly, action in the world is closely tied to dialogue with others. The inquiry cycle presents aspects of inquiry that need support in a successful learning environment. As such, it serves as a boundary object (Star & Griesmer, 1989), allowing us to relate theory with ordinary practices or to look across modes and contexts of learning. The cycle can thus be used to inform and guide educational experiences for learners. It is important to note that it is merely suggestive, neither the sole, complete, nor rigid characterization of inquiry-based learning. In actuality, inquiry rarely proceeds in a simple, linear fashion. The five dimensions in the process—ask, investigate, create, discuss, reflect—overlap, and not every category or step is present in any given inquiry. Each step can be embedded in any of the others, and so on. In fact, the very nature of inquiry is that these steps are mutually reinforcing and interrelated. Despite these complexities, the cycle highlights aspects of an otherwise opaque process. The "ask" dimension reminds us that inquiry develops from a question or problem arising out of experience. Meaningful questions are inspired by genuine curiosity about real-world experiences and challenges. The indeterminate situation Dewey refers to is part of that experience, including

		an individual's participation in a community. It is not something that can be delivered from "outside" this participation. An example of this comes from an early study of learning with computers. Researchers found that students became most engaged when there was a bug in the computer learning software. They had a genuine interest in exploring the behavior of the bug, which led to deep inquiry about programming. The researchers noted the "enormous pedagogical difference between answering someone else's question and formulating your own" (Olds, Schwartz, & Willie, 1980, p. 40). But it is important to caution that inquiry does not always start with a well-articulated question. In fact, questions themselves arise from reflection and action in the world, including dialogue with others. Elspeth Huxley (1959) stated this well: The best way to find things out. .. is not to ask questions at all. If you fire off a question, it is like firing of a gun—bang it goes, and everything takes flight and runs for shelter. But if you sit quite still and pretend not to be looking, all the little facts will come and peck round your feet, situations will venture forth from thickets, and intentions will creep out and sun themselves on a stone; and if you are very patient you will see and understand a great deal more than a man with a gun does. (p. 272) The "investigate" dimension relates to the varieties of experience possible and the many ways in which we become part of an indeterminate situation. It suggests that opportunities for learning require diverse, authentic, and challenging materials and problems. Because experience includes interactions with others, there is also a moral dimension to inquiry. Similarly, physical, emotional, aesthetic, and practical dimensions are inherent in inquiry, and are not merely enhancements or add-ons. Through investigation, we turn curiosity into action. Learners gather information, study, craft an experiment, observe, or interview. The learner may recast the question, refine a line of query, or plunge down a new path that the original question did not, or could not, anticipate. The information-gathering stage becomes a self-motivated process that is owned by the engaged learner. The "create" dimension picks up the "controlled or directed transformation" part of Dewey's definition of inquiry. This term reminds us that inquiry means active, engaged, hands-on learning. Inquiry thus implies active creation of meaning, which includes new forms of collaborating and new roles for collaborators. As information begins to coalesce, the learner makes connections. The ability at this stage to synthesize meaning is the creative spark that forms new knowledge. The learner now undertakes the creative task of shaping significant new thoughts, ideas, and theories, extending his/her prior experience. The "discuss" dimension highlights an implicit part of Dewey's definition. Although inquiry has a personal aspect, it is also part of our participation in social arrangements and community. The discuss aspect in the Inquiry Cycle involves listening to others and articulating our own understandings. Through discussion (or dialogue),

		construction of knowledge becomes a social enterprise. Learners share their ideas and ask others about their own experiences. Shared knowledge is a community-building process, and the meaning of their investigation begins to take on greater relevance in the context of the learners' society. Learners compare notes, share experiences, and discuss conclusions, through multiple media, including now online social networks. The "reflect" dimension tells us that only the inquirer can recognize the indeterminate situation and further, say whether it has been transformed into a unified whole. Reflection (later articulated in the work of Sch¨on, 1987, and others) means expressing experience, and thereby being able to move from new concepts into action. Reflection may also mean recognizing further indeterminacies, leading to continuing inquiry. Reflection is taking the time to look back at initial questions, the research path, and the conclusions made. The learner steps back, takes inventory, makes observations and new decisions. Has a solution been found? Do new questions come into light? What might those questions be? And so it begins again—thus the circle of inquiry. (p. 194-195).
2	Buck, Akerson, Quigley, & Weiland (2014) Exploring the Potential of Using Explicit Reflective Instruction through Contextualized and Decontextualized Approaches to Teach First-Grade African American Girls the Practices of Science Electronic Journal of Science Education	In the elementary schools in our university/school partnerships, we sought to begin this path to understanding the scientific practices by formally introducing the practices of observation, inference and evidence. Empirical evidence refers to qualitative and quantitative data used to develop and confirm scientific ideas. These empirical data are derived from observation using the five senses and scientific inferences which are logical interpretations based on these observations and prior knowledge. Science education research has shown that young children can attain informed formal understandings of these specific practices, and has provided teachers with specific pedagogical strategies that enhance that attainment (e.g., Akerson & Volrich, 2006; Khishfe & Abd-El-Khalick, 2002; Metz, 2004). (p. 2). The term 'practices' is used throughout the documents to refer to the activities of scientists that are done repeatedly with increasing levels of proficiency (e.g., Bybee, 2011; Michaels, Shouse, & Schweingruber, 2008). By repeatedly engaging in the practices of science, students "form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students' knowledge more meaningful and embeds it more deeply into their worldview" (National Research Council, 2012, pg. 42).(p. 2)

3	Decristan et al. (2015) Impact of Additional Guidance in Science Education on Primary Students' Conceptual Understanding Journal of Educational Research	Good science teaching and learning has been framed as (scientific) inquiry (e.g., Anderson, 2002); this framework refers to instructional environments that allow students to construct knowledge through a process of active scientific investigation und evaluation of empirical evidence. (p. 358)___ Furtak, Seidel, Iverson, and Briggs (2012) suggested defining inquiry in terms of two dimensions: a cognitive and a guidance dimension. Regarding the cognitive dimension of inquiry, Minner et al. (2009) concluded, "having students actively think about and participate in the investigation process increases their science conceptual learning" (p. 20). Consistently, Duschl (2008) identified conceptual, epistemic, and social aspects of inquiry. The conceptual domain includes knowledge on science concepts and principles, the epistemic domain consists of knowledge on how scientific understanding is generated, and the social domain comprises collaborative and communicative processes for the construction of science knowledge. To realize these aspects of inquiry, science curricula should, for instance, include cognitively challenging and authentic tasks and materials, evidence, scientifically orientated questions, and student discussion and argumentation (see also Furtak et al., 2012). Regarding the guidance dimension, IBSE has been commonly classified according to the degrees of freedom with which the students operate, that is, the degree of guidance for inquiry (e.g., Bell, Smetana, & Binns, 2005), accompanied by a debate on the effectiveness of open or minimally guided versus guided inquiry (e.g., Hmelo-Silver, Duncan, & Chinn, 2007; Kirschner, Sweller, & Clark, 2006). Typically, the degree of guidance has been defined by the role of the teacher during learning activities (i.e., ranging from student-directed to teachersupported inquiry). However, guidance can also be provided to students by curriculum or by peers (see Furtak et al., 2012). High levels of guidance are particularly important for fostering student learning when the subject matter is complex and challenging and prior knowledge is limited (e.g., Hardy, Jonen, M€oller, & Stern, 2006; Hmelo-Silver et al., 2007). Despite the large body of research in science education, educational practice is far from what scientists have proposed (e.g., Treagust & Duit, 2008), and teachers and students are often challenged to reach the curricular learning goals. In general, conceptual development is considered to be a slow and gradual process rather than a dramatic gestalt-type shift between paradigms (Caravita & Hallden, 1994). Children spontaneously construct their own explanations of scientific phenomena through their daily life experiences (Carey, 2000). From a scientific point of view, however, students' preinstructional conceptions are often partially or entirely inadequate. Furthermore, conceptual understanding places high demands on students' language proficiency because inquiry involves analyzing, summarizing, and presenting science

		information in oral or written formats (Lee & Fradd, 1998). Sufficient language proficiency is needed for understanding written tasks, explaining and discussing science concepts, and participating in collaborative and communicative processes for the construction of conceptual understanding (e.g., Akerson, Flick, & Lederman, 2000; Osborne, Erduran, & Simon, 2004; van Boxtel, van der Linden, & Kanselaar, 2000). Accordingly, oral and written language skills are closely connected to both the cognitive and the guidance dimensions of inquiry. However, because high levels of guidance makes complex learning more tractable and difficult tasks more manageable (Hmelo-Silver et al., 2007), additional guidance may provide particular support to students with poor language proficiency, and hence be especially beneficial for students at risk of not achieving the curricular learning goals in science.(p. 360)
4	Delclaux & Saltiel (2013) An Evaluation of Local Teacher Support Strategies for the Implementation of Inquiry-Based Science Education in French Primary Schools Education 3-13 International Journal of Primary, Elementary and Early Years Education	La main a ` la pa ˆte's programme advocates an inquiry-based pedagogy which incites children to explore the world around them through observation and experimentation, to acquire scientific content knowledge, to reason and to master the use of language and argumentation. (p. 138) Inquiry-based science education comprises experiences that enable students to develop understanding about the scientific aspects of the world around through the development and use of inquiry skills' (Harlen and Allende 2009, 10). (p. 139) The French programme shares this broad definition of inquiry. The main goal is to contribute to the development of children's curiosity, their creativity, their critical thinking and reasoning skills, and their mastery of language and argumentation, through science in school (see La main a` la paˆ te 2000; Saltiel 2006; Sarmant, Saltiel, and Le´ na 2011). La main a ` la pa ˆte promotes an open form of inquiry: under the teacher's guidance, children are expected not only to carry out experiments, but also to raise research questions and to suggest possible ways of finding answers to those questions.(p. 139)
5	Desouza (2017) Conceptual Play and Science Inquiry: Using the 5E Instructional Mode	Inquiry is vital to science teaching. One of the most influential instructional models in science education is the 5E instructional model (Bybee et al., 2006). Developed by the Biological Sciences Curriculum Study, the 5E model gets its phases and sequence of instruction from the Learning Cycle model (Atkins & Karplus, 1962) which originally constituted of the exploration, explanation (concept formation) and extension (expansion) phases. This 3E learning cycle is based on Piaget's mental functioning model (Marek, 2008). The 5E instructional model is established on the constructivist approach to learning which operates under the assumption that learners bring with them ideas of the world around them and they construct knowledge

	Pedagogies: An International Journal	by testing new ideas against the existing ideas that they know to be real. When new ideas are familiar, they are easily assimilated and learners use the process of accommodation to fit unfamiliar ideas of how the world operates (Colburn, 2003). The research-based 5E model also incorporates the notion that learning takes place in a social setting and that cooperation, collaboration and co-construction of ideas are essential for learning. While the stages in the 5E instructional model are itemized in a linear manner, they are most effective when used in a cyclical manner. In a guest editorial, Bybee (2014) re flects upon the design of the 5E model and responds to questions, makes recommendations and enumerates the implications for its usage and its applications in the era of the Next Generation Science Standards (NGSS, 2013). He recommends that it would be preferable to have a timeframe longer than a class period as it gives students more time to experience each stage. While he suggests that the model would be effective for a unit of study spanning 2–3 weeks, it would lose its effectiveness if it were used for a longer period of time. According to Bybee, research shows that omitting a phase (Bybee et al., 2006; NRC,1999) or rearranging the sequence of phases (Renner, Abraham, & Bernie, 1988) would result in losing the sequence and integrity of the learning cycle model. This aspect might seem that the model is inflexible and thus not suitable for early childhood curriculum; the repetition of phases, however, gives children the chance for extended exploration and reflection. Teachers are allowed the flexibility to add prerequisite information before and after the explanation stage, or where they deem necessary. The 5E instructional model has been used in the primary grades (Yoon & Onchwari, 2006); however; its use in preschool settings is still in the fledgling stage (Miller et al., 2013). Over the last century, early childhood pedagogies have been greatly influenced by Piaget's notion of children's investigative competencies, and that learning experiences were designed to be compatible with children's play-based stages of development (Hatch, 2010). (p. 342) Integrating conceptual play in the 5E instructional model The NSTA (2014) position statement on early childhood science education declares that it is important for teachers and educators to recognize and nurture children's curiosity, and to focus on content and practices of science that lead to the understanding of how these experiences connect to the science content as defined by the Next Generation Science Standards (NGSS Lead States, 2013). Given that an academic need has arisen, a modified version of the 5E model was used in a science methods course at a Midwestern university in the United States. In a qualitative research study, 20 young children (4-year olds) from a Child Development Centre, in the Midwest, were taught by the preservice teachers enrolled in the course, Teaching Science in the Elementary School designed for early

		childhood and elementary education majors. The participation in a field study is a requirement for this course, the lesson plans, observations of children's interaction with peers and adults in the learning process, and reflections are assigned activities for the field experience. However, participation in the research study was voluntary. During the first few weeks of classes, the preservice teachers learned how to design inquiry-based learning activities using the modified 5E version of the instructional model specifically, for an outdoor setting. The Child Development Centre has acreage that is designed for exploratory activities to take place in a natural setting. During their outdoor time, the preschoolers are frequently observed climbing logs of wood that are aesthetically placed on the grounds, or building a dam across a ditch with pieces of wood. At other times, they are chasing a frog across the open space or exploring every crevice looking for spiders. The children are so excited to experience the freedom of space as well as the independence to learn by discovery. During each session of the field experience, the preschoolers were assigned to a group of preservice teachers who engaged them in an outdoor inquiry-based lesson that was planned to incorporate topics such as plant and animal characteristics, habitats and other concepts related to the landscape. Bybee et al. (2006) attribute the success of the 5E model of instruction to its robust construction. This model consists of five stages, namely, engage, explore, explain, elaborate and evaluate. A description and purpose of the phases in the 5E instructional model are presented within the text of a lesson. A discussion of how each stage is interpreted as conceptual play and is important to the development of a science concept as perceived from a cultural–historical viewpoint is presented in the next section. (p. 344)
6	Eckhoff (2017) Partners in Inquiry: A Collaborative Life Science Investigation with Preservice Teachers and Kindergarten Students Early Childhood Education Journal	In particular, this research is framed by understandings of guided inquiry-based instruction (Trundle et al. 2010) and the related importance of science pedagogical practices building upon contemporary understandings of young children's intuitive scientific thinking and exploration (Gopnik 2012). The work between PTs and kindergartners during this project is based upon a fundamental understanding of the role of the early childhood teacher as guide, facilitator, and provocateur (Wien 2014) with robust science content and pedagogical knowledge. Inquiry-based learning incorporates central tenets of reform-based teaching such as active learning and the integration of new knowledge with existing, prior knowledge (Bransford et al. 2000). Inquiry experiences are most often centered on a specific science topic broken down into smaller investigations for focused exploration (Krajcik et al. 2003). In a 2014 position statement the National Science Teachers Association (NSTA) stressed the need for reflective, inquiry-based science experiences at the early childhood level in order to support and strengthen student learning. The National Research Council recommends the inclusion of inquiry science experiences at the early childhood levels (NRC 2007, 2012).

		Recommended early science learning experiences that drive a guided, inquiry based include: identifying and asking questions that can be answered through investigation, designing and conducting investigations, using appropriate tools and equipment, learning to develop logical conclusions, and communicate understandings to peers and others (NSTA 2004).A crucial component of guided inquiry in science is the ability of young children to share and express ideas. Unlike older children who have the ability to express and share ideas through the processes of reading and writing, early childhood students are beginning to build early literacy skills. Thus, preschool and early grades teachers are faced with the challenge of finding alternative ways to encourage their students to explore the ideas of others and to express their own thinking. Representation of student thinking is an important element of inquiry-based experiences as different forms of representation work to encourage young children to make their thinking visible to themselves and others. In early childhood science, student representation can be expressed though various forms of visual arts media including student drawings and digital photography (p. 220) Drawing during science experiences can serve to support engagement, representation of student understandings, and as a strategy for learning (Ainsworth et al. 2011). Students' science-related drawings allow teachers to embed meaningful, formative assessment into the science learning experience. Likewise, digital images captured during science explorations can serve as a form of representation. Digital images taken by the students can be used to: document and communicate their experiences, collaborate with other students, promote observation, recall or activate schema, increase self-expression efficacy, and prompt discussion (Blagojevic and Thomes 2008; Neumann-Hinds 2007).(p. 220)
7	Enyedy, Danish, Delacruz, & Kumar (2012) Learning Physics through Play in an Augmented Reality Environment International Journal of Computer-Supported Collaborative Learning	With support, early elementary students can engage in productive inquiry, collect and analyze data, produce models, and learn complex concepts. (P.347) One of the most promising for young children is scientific modeling. Studies have shown that asking students to produce and evaluate models of the real world to help them generate predictions can make it possible for them to effectively participate in the process of scientific knowledge production and learn the content being studied (Lehrer and Schauble 2006).(p. 348) Our overarching intent for our activities was for them to be the sparks and anchors for modeling conversations. That is, we want students to make observations in an environment that is structured by both

		the teacher and our designed tools. The tools are intentionally made to be adaptable so that students can represent their own emerging understandings, no matter how accurate or inaccurate they may be. The models students create are then shared, critiqued and refined within the classroom community with the goal of producing a shared collective model that can be used to understand and make predictions in new situations and contexts Our overarching intent for our activities was for them to be the sparks and anchors for modeling conversations. That is, we want students to make observations in an environment that is structured by both the teacher and our designed tools. The tools are intentionally made to be adaptable so that students can represent their own emerging understandings, no matter how accurate or inaccurate they may be. The models students create are then shared,critiqued and refined within the classroom community with the goal of producing a shared collective model that can be used to understand and make predictions in new situations and contexts. (p. 348) There were two key components to the LPP system: 1) an augmented reality system that uses computer vision to record and display the students' physical actions and locations, and 2) software that translates this motion into a physics engine and generates a response based on the sensing data. The LPP system uses commercially available, open source forms of motion tracking and pattern recognition technologies (Kato, 2006) to create an inexpensive alternative to virtual reality within the physical classroom (a 12' x 12 ' carpet at the front of the classroom). Motion tracked by the system is instantly imported into the new LPP computer microworld that allows students to model their understanding of force and motion and compare their predictions to simulated results. (p. 349)_ The defining feature of pretend play is not that it is fun (although it often is). Rather, its defining feature is the combination of an imaginary situation with a set of rules (Vygotsky 1978). Play can be seen as a continuum with pretend play on one end, where the imaginary situation is rich and explicit but rules tend to be understated and implicit, and games on the other end, where rules are explicit and the imaginary situation is thinner or more symbolic (Vygotsky 1978). However, in all forms of play, students are able to engage with quite complicated rule sets. For example, when "playing house," children typically control their behavior based on a set of rules about what fathers do, what mothers do, and what babies do. It is this focus on a set of rules that makes play relevant to science, as scientific phenomena are often described as a set of rules or laws—for example, Newton's three laws of force and motion. The rules in pretend play are also

		what make play a valuable part of the learning. In play, children often attempt to govern their behavior by following a set of rules that they do not yet fully understand. Thus, in play children externalize their intuitions making them visible for reflection and/or comment by others. For young children play presents an alternative to the traditional ways of eliciting intuitions through verbal or written explanations and/or predictions (diSessa 1993). Additionally, an oddity of children's socio-dramatic play is that children often spend more time articulating and negotiating the rules of a play situation than they spend actually in character "playing" their parts (Cooper, 2009). Because of this constant negotiation and reflection on their play activity, in terms of what they did, why they did it, and what happened as a result, the rules that govern a situation become visible and explicit for children. In this way, children use play to come to a deeper understanding of the rules governing the real world through a type of informal inquiry and simulation (Youngquist and Pataray-Ching 2004).(p. 353) Young children and the concepts of force and motion The reason we chose to create an augmented-reality modeling environment to teach Newtonian force and motion was because we saw a fit between children's development, learning theory, and the affordances of the new technologies. Physics is often cited as a privileged domain, where young children have a rich set of experiences to draw upon long before they enter school (Bransford, et al. 2000). In infancy, children develop an intuitive notion of objects, including their permanence and their properties. By preschool these intuitions have developed into a sophisticated sense of mechanical causality and understanding of the links between unseen causes and observable results (Bullock, et al. 1982; Yoachim and Meltzoff 2003, October). Additionally, pre-school children can distinguish between distance, speed, and time when observing objects in motion (Acredolo, et al. 1984; Matsuda2001). Even so, some concepts of force and motion are difficult for young students to grasp and these conceptual difficulties often persist well into college (e.g., White 1993a, b). Given the rich set of intuitions that young children have about force and motion, the prominence and import of force and motion in the K-12 curriculum and beyond, and the existing research into students' conceptual intuitions and the interventions that have successfully helped students develop normative understandings, we chose force and motion as an ideal test bed to develop and studya new computer-supported, collaborative modeling approach to early elementary science instruction (p. 350).
8	Fridberg, Thulin, & Redfors (2018)	Studies of small children show that learning presupposes an object as well as an act (Pramling 1990, 1994; Marton and Booth,1997), and in preschool, the object of learning is the least focused of the two.

	Preschool Children's Collaborative Science Learning Scaffolded by Tablets Research in Science Education	Developmental pedagogy, as depicted by Pramling Samuelsson and Asplund Carlsson (2008), takes into consideration the importance of a teacher who supports and encourages the child's willingness to make sense of the world and a teacher capable of tuning into the child's world to share the same learning object for communication and thinking. In order to help a child develop its perception and understanding of the world, the teacher's approach should be one of variation (MartonandBooth 1997).Forexample,fora child to understand the concept of flowers, the child must discover what critical aspects separate a flower from grass or a tree. The child needs the experience of a variety of flowers in order to distinguish the essential features constituting a flower and gradually, he or she will become able to understand what defines a rose, as compared to other flowers (Pramling Samuelsson and Asplund Carlsson 2008). Developmental pedagogy defines learning as the variety of ways in which one child produces variation and the variety of ways a group of children think about one and the same phenomenon or concept. Accordingly, the teacher uses variation as a strategy to make a particular phenomenon visible to a child. As several children think in various ways about a concept or phenomenon, comparing and discussing these thoughts may make different meanings and features appear to the child/children (Pramling Samuelsson and Asplund Carlsson, 2008). According to Eshach (2006), science could be thought of as comprising two types of knowledge: domain-specific knowledge and domain-general knowledge/strategies.The former refers to the knowledge of a variety of phenomena (e.g. atoms, forces, magnetism, chemical reactions) or in other words the knowledge of theoretical models of real world objects and events. The latter refers to skills needed for reasoning about science in terms of, for instance; experimental design or evidence evaluation; skills such as observation; formulation of hypotheses; data collection, and represention of data with graphs or diagrams (Keys 1994; Schauble et al.1995; Zimmerman 2000). Domain-specific knowledge and domain-general knowledge together contain conceptual and procedural aspects of science. However, as mentioned above, underlying this paper is the need to synthesise the knowledge of content (concepts, theories, theoretical models) and investigation (hypotheses, problematizing, questions, experiments) for young children's effective science learning. Also Vygotsky (1987) argued that research tends to focus on the end product of the process, rather than on how the concept formation begins and develops. As Fleer (2009) concludes, studying the dynamic process as opposed to the child's definitions of a particular concept, or end product, offers a new direction for science education research, especially for researchers who, like ourselves, are interested in how young children pay attention to and extend their understanding of scientific concepts (p. 1010)

		The activities were multi-faceted and always aimed to take a starting point from the children's experiences. Researcher, teacher and a dialogue with the children led to the choice of phases and phase changes of water as the science content. (p.1011) The working process designed and performed in this study aimed at starting in the world of the children and synthesising the specific and general domain-knowledge described by Eshach (2006).That is, content (concepts, theories, theoretical models) and investigations (hypotheses, problematizing, questions, experiments) for young children's effective science learning. From the results, it was evident that the physically active contexts of experimentation with and without timelapse photography and production of Slowmations promoted the children's more advanced reflections about both the natural phenomenon, i.e. water phases, and creative representations and problem solving (p. 1022)
9	García-Carmona, Criado, & Cruz-Guzmán (2017) Primary Pre-Service Teachers' Skills in Planning a Guided Scientific Inquiry Research in Science Education	IBSE is pedagogically complex, and the concept does not have a single meaning (Garritz 2012; Newman et al.2004). In general, however, it is characterized by being an educational approach which: … means students progressively developing key scientific ideas through learning how to investigate, and building their knowledge and understanding of the world around them. They use skills employed by scientists such as raising questions, collecting data, reasoning and reviewing evidence in the light of what is already known, drawing conclusions and discussing results (Inter-Academy Partnership [IAP] 2010, p. 19). Among other things, this perspective on science learning requires the pupils to carry out ExA (Caamaño 2012; Criado and García-Carmona 2011; Harlen2014). Pupils will observe, investigate, and develop an understanding of natural phenomena through direct experience with those phenomena (Science Community Representing Education [SCORE] 2013). They will therefore be able to make use of basic scientific skills in order to learn science by doing science (Hodson 2014). The promotion of ExA is thus a recommended starting point for the initial levels of education (Harlen 2014). (p. 990) there seems to be some agreement that scientific inquiry has the following characteristics (Lederman et al. 2014): (i) all scientific inquiries begin with a question or problem that does not necessarily have to be oriented to testing a hypothesis; (ii) there is no single set of steps to be followed in every inquiry, i.e., there is no single scientific method; (iii) scientific inquiry processes are guided by the question that has been posed; (iv) different researchers following the same process may get different results; (v) the inquiry processes followed may influence the results; (vi) the conclusions of the research must be consistent with

		the data acquired; (vii) the scientific data (numbers, descriptions, images, etc.) are not the same as scientific evidence (product of data analysis and interpretation); and (viii) the explanations (inferences) are developed from a combination of the data that has been acquired and what is already known in science about the phenomenon. As mentioned above, hypothesis formulation is not necessary nor even appropriate in all scientific inquiries, although in most of them it is. Hypotheses are statements of tentative solutions to the problems so as to guide the development of the inquiry. Depending on the nature of the inquiry, three types of hypothesis can be distinguished (Guisasola et al. 2006): & Descriptive hypotheses, stating something that has not yet been confirmed. Such a hypothesis is related to factual knowledge (events, phenomena, facts). & Explanatory hypotheses, speculating about the reasons why things are as they are. These hypotheses relate to knowledge of the Bwhy^ (explanations, models, theories…). Predictions are made from this type of hypothesis through deductive reasoning. The predicted result would be that reached if the hypothesis were true. & Procedural hypotheses, referring to knowledge of the Bhow^ to carry out experiments, make measurements, and other procedural practices. Such a hypothesis is related to doing, modifying, and refining test and measurement methods.(p. 991) Confirmation inquiry. The teacher presents the pupils with a question and indicates the procedure to follow to obtain results known beforehand, in order either to confirm or strengthen a scientific idea, or to practice specific skills of data acquisition and organization. & Structured inquiry. The question and the procedure are still set out by the teacher, but now the pupils have to construct a scientific explanation using the data they recorded and the evidence these data provide. & Guidedinquiry.Thepupils now design and follow their own procedures to collect data and draw conclusions in response to a question posed by the teacher. & Open inquiry. The pupils formulate their own questions for inquiry, and design and carry out their own procedures, collect the data, and report their findings and conclusions.(p- 992)
10	Gropen, Kook, Hoisington, & Cark-Chiarelli (2017) Foundations of Science Literacy: Efficacy of a Preschool Professional Development Program in Science on Classroom	FSL's ultimate goal is to build preschool children's ability to engage in inquiry and use inquiry skills such as exploring, asking questions, making predictions, investigating, observing, collecting and recording data, and generating and reflecting on their science ideas. (P. 610) The pedagogical tools introduced in FSL include the inquiry learning cycle, the open/focused exploration framework, the engage–explore–reflect (E-E-R) cycle, and a set of Talk Tips. The inquiry learning cycle, as depicted in Figure 1, illustrates the nature of inquiry as both an iterative process and a set of skills. It reminds teachers that science inquiry for children is not a linear, step-by-step process but a spiraling, dynamic one. The open/focused exploration framework integrates two key ideas: (a) Opportunities for

	Instruction, Teachers' Pedagogical Content Knowledge, and Children's Observations and Predictions Early Education and Developmen	unstructured play with objects and materials are a prerequisite to jumpstarting the inquiry process; and (b) more focused, structured investigations build on early experiences and provide a context for more specific questions. This framework reminds teachers that they can promote conceptual development during a long-term study by providing children with initial open and then progressively more focused explorations that are responsive to children's prior experience, interests, and questions. The E-E-R cycle is the central pedagogical tool of FSL and can be regarded as a simplified version of the inquiry learning cycle shown in Figure 1. It is an adaptable model that teachers can use to support iterative cycles of inquiry throughout the study of a topic during both open and focused explorations. E-E-R contextualizes inquiry and supports teachers' efforts to draw out children's prior knowledge and invite predictions (engage); encourage children's direct investigation, observation, and data collection (explore); and help children reflect on their observations and share their evidence-based ideas (reflect). This cycle is explicated further in an upcoming section (p. 611).
11	Hollingsworth & Vandermass-Peeler (2017) "Almost Everything We Do Includes Inquiry": Fostering Inquiry-Based Teaching and Learning with Preschool Teachers Early Child Development and Care	The term inquiry is used to describe the processes and strategies of learning in any domain, but it can also include skills specific to a particular curricular area (Menmuir & Adams,1997).Processes and skills related to inquiry-based learning have often been studied inconjunction with mathematics and science in early childhood educational contexts (e.g. Epstein, 2007; French, 2004;Gerde, Schachter, & Wasik, 2013;Menmuir&Adams,1997).Early inquiry-based learning opportunities afford preschoolers the chance to build on their inherent fascination with the functioning of the natural world through social collaborations in 'experience-rich and language-rich environments' (French, 2004, p. 147) (p. 152). Thus, children do not just learn scientific facts from static, prescribed curriculum units, but instead learn to think like scientists by exploring big ideas and learning the language and practices of science (Gelman & Brenneman, 2012; Wasserman, 2015). In constructive, inquiry-based early childhood educational approaches to teaching science, children develop conceptual understanding and also practice using related skills and tools (French, 2004; Gelman et al., 2010; Greenfield et al., 2009; Inan et al., 2010). In addition, inquiry-based learning is cyclic. As children continue to develop knowledge, they seek new opportunities through which to apply their emergent scientific thinking and reasoning skills (Gelman & Brenneman, 2004). The process of inquiry also enables children to integrate language, literacy, math, and science educational experiences (Epstein, 2007; Gerde et al., 2013; Greenfield et al., 2009). Evidence and theory

		support the assumption that preschool children learn best when linking extant and new knowledge through hands-on experiences (Bjorklund, 2011; Gelman & Brenneman, 2012; Greenfield et al., 2009). (p. 153)
12	Howitt, Lewis, & Upson (2011) It's a mystery!' A case study of implementing forensic science in preschool as scientific inquiry Australasian Journal of Early Childhood	Inquiry-based learning Contemporary learning theory states that learning is most effective when students are active participants within the learning process, when the learning proceeds from experiences to explanations, when students' existing knowledge is used as the platform to develop new explanations, and when teachers are prepared to support students in the learning process (Anderson, 2002; Hackling, 2007). An inquiry-based approach to learning, where students are actively involved in finding answers to their own questions, incorporates all of these conditions. Learning science through an inquiry approach involves students in asking questions, exploring and investigating phenomena through the manipulation of materials, gaining experiences and making observations, and then developing explanations for those experiences (Hackling, 2007). At the heart of inquiry-based learning is the student trying to make sense of the phenomena under study (Crawford, 2009). As such, this approach actively engages students in learning, encourages curiosity and excitement of discovery, develops knowledge and understanding of scientific ideas, supports students in using data as evidence, and allows students to experience working like a real scientist (Anderson, 2002; Crawford, 2007). Within early childhood education, inquiry learning appears to commonly follow that of guided inquiry. A guided inquiry approach provides structured experiences of the phenomenon and leads to the collection of observations that can be used to develop explanations for the phenomenon (Hackling, 2005). Guided inquiry therefore involves guided and collaborative participation (Hedges, 2000) between the teacher and children through steps that may involve manipulating materials; making observations or measurements; or recording, discussing or interpreting observations (Hackling, 2005). Guided participation acknowledges the role of children as 'active agents and communicators in their own learning' (Hedges, 2000, p. 18). One of the key issues in guided inquiry is to select an appropriate context and learning experiences that allow young children to create meaningful new knowledge, based on the cognitive resources they bring to the task (Samarapungavan et al., 2008). These authors further commented on the need to provide appropriate instructional support, as young children are 'universal novices' (p. 903), lacking experiences with science as a discipline as well as having limited cognitive tools for literacy and numeracy. Such support included modelling aspects of inquiry, guiding science discourse, and assisting young children to better understand the scientific inquiry process (Samarapungavan et al., 2008). There appears to be limited research on the outcomes of inquiry learning on young children. However, a few relevant studies were located. Samarapungavan et al. (2008) examined United States

		kindergarten (no age given) children's science learning, using a guided inquiry approach into the life cycle of the monarch butterfly. Their results indicated that kindergarten children were able to successfully engage in the practices of scientific inquiry and to conduct empirical investigations to extend and revise their biological knowledge. As measured through an analysis of portfolios, they found the children were highly proficient in generating questions, making predictions, observing and recording data, and communicating their findings, while proficient in using empirical evidence to extend, elaborate or revise their knowledge. Also in the United States, Peterson and French (2008) examined preschool (three- and four-yearold) children's explanatory language through science inquiry in a five-week unit on colour mixing. Through analysis of discourse the children were found to engage as conversational partners, scientific investigators and dynamic co-constructors of explanations. These results demonstrate that young children can successfully engage in scientific explanation and inquiry. (p: 46-47)
13	Ilhan & Tosun (2016) Kindergarten Students' Levels of Understanding Some Science Concepts and Scientific Inquiry Processes According to Demographic Variables (The Sampling of Kilis Province in Turkey) Cogent Education	The aim of preschool science education is to provide children with the basic knowledge on the occurrence of phenomena and events in nature and help them understand themselves and their environment (Sahin, 1997). The science education to be given to children in this period should be directed toward satisfying the curiosity of children, rather than providing information on scientific concepts (Kefi, Çeliköz, & Erişen, 2013). Science education where the science concepts are merely recited to students or which is based on memorization does not contribute much to the mental development of children. Consequently, the learned information accumulates irregularly and gets forgotten in a short time. In science education, where activities are performed and students are active, on the other hand, children who are introduced to science activities will refrain from scientific works in the following years unless they get sufficient support from their teachers and if they have negative experiences (Simpson & Oliver, 1990). According to Kamay and Kaşker (2006), children start to learn and use the basic concepts of mathematics and science education in the preschool period. According to Kefi and Çeliköz (2014), this period is full of experiences in which children acquire basic concepts and scientific process skills. It is important to include activities in which children can use or develop scientific process skills along with the basic knowledge, understanding, attitude, and values regarding science (Boyuk, Tanik, & Saracoglu, 2011). Children should be introduced to such skills in the preschool period so that they can use the scientific process skills effectively in future years (Kefi et al., 2013). Scientific process skills are essential skills that every individual should have in order to become a science literate. The best time to introduce children to science is the preschool period when they start to get curious about the world surrounding them. When children have the ability to use their scientific process

		skills, it is easier for them to reach new knowledge through concrete experiences and gain such knowledge (Harlen & Qualter, 2004). (p.2) _ Scientific process skills are essential skills that every individual should have in order to become a science literate. The best time to introduce children to science is the preschool period when they start to get curious about the world surrounding them. When children have the ability to use their scientific process skills, it is easier for them to reach new knowledge through concrete experiences and gain such knowledge (Harlen & Qualter, 2004). (p. 2) According to Cepni et al. (2006), those skills are divided into three groups: basic skills, causal skills, and experimental skills. Among those skills, basic scientific process skills are gained since birth. The most frequently repeated basic scientific process skills are observation, estimation, classification, using numbers, communication, measurement, data recording, problem-solving, and reasoning skills (Howe & Jones, 1998). Hypothesizing, defining hypothesis, and data checking skills are more advanced level scientific process skills that develop after preschool periods (Lind, 2000). According to Kefi et al. (2013), it is not possible to gain the scientific process skills, which are expected to be gained in further ages, effectively without developing the basic scientific process skills. (p. 3) SIP which are presented as follow: (i) "Understand science as a process of inquiry is based on asking questions and making predictions about the natural world;" (ii) "Understand the empirical basis of science: Scientific ideas are evaluated by their correspondence or fit to empirical evidence;" and (iii) "Understand simple tools used to gather, record, analyze, and share data.(P.5)
14	Kallery, Psillos, & Tselfes (2009) Typical Didactical Activities in the Greek Early-Years Science Classroom: Do They Promote Science Learning?	It can be argued that understanding science implies also some understanding of the practices involved in scientific inquiry, aspects of which are essential for the teaching of scientific subjects. Hacking (1992, 1995), by mapping the actual laboratory science activities practiced by scientists and subjecting them to a systematic bottom-up analysis, suggested that theoretical ideas, evidence and material world are entities internal to scientific inquiry and that making connections between them is characteristic of scientific practice. Based on Hacking's framework, Psillos, Tselfes and Kariotoglou (2004) suggested that, in educational contexts, establishing connections between theoretical ideas, evidence and material world is essential in assisting children's understanding in science and their scientific thinking._(p. 1188)

	International Journal of Science Education	The teaching of science through inquiry methods aims at enabling young children to obtain experiences that are authentic to scientific experience (Peters, 2006), and is thought to make their learning more meaningful and to improve their scientific understanding (Hogan 2000; Hogan & Maglienti, 2001). Inquiry is considered by many (e.g. de Boo, 2000; Lind, 1999; Novak, 1977) as a major area of interest in young children's education in science. Research findings overwhelmingly support the teaching of science through inquiry (see Lind, 1999); and National Science Education Standards (NSES, American National Research Council, 1996) advocates, in line with the guidelines from the Association for the Education of Young Children (Bredekamp & Copple, 1997), that children at all grade levels and in every domain of science be given the opportunity to use scientific inquiry and to develop the ability to think and act in ways associated with scientific inquiry, including skills such as conducting investigations, using appropriate tools and techniques to gather data, thinking critically and logically about relationships between evidence and explanations, and communicating scientific arguments. Co-ordination of evidence and theory involves inquiry skills, which is why inquiry is considered inherent to science. It involves scientific thinking that relies on both concepts and procedures, the latter being those we 'tend to have in mind when we speak about scientific thinking as analytical and critical thinking or, especially, the thinking which connects evidence and theory' (emphasis added) (Eshach & Fried 2005, p. 327). Yet learning with understanding involves the development of ideas through the learner's own thinking and action, and in science this means developing the skills to deal with new situations (Harlen, 1996). Lind argues that pre-primary-level science is an active enterprise '…seen as a way of thinking and trying to understand…'. Educators should, therefore, aim at introducing young children to the investigative nature of science, fostering their understanding and use of the modes of reasoning of scientific inquiry and relating new science knowledge both to previously learned knowledge and to new experiences of phenomena (Lind, 1999; NSES 1996). (p.1189) ___ These situations must be planned in advance. Educators, whose role is to lead children in their conceptual thinking (Fleer, 1993), should provide them with appropriate materials and activities, progressively increasing in conceptual depth and complexity, in order to develop their scientific reasoning (Bredekamp & Cople 1997; Eshach & Fried, 2005; Lind, 1999). (p. 1190). As was discussed earlier, theoretical ideas, evidence and the material world are, according to Hacking (1992), entities internal to scientific inquiry and, in educational contexts, connections between them are essential in assisting children's understanding in science and their scientific thinking (Psillos et al., 2004) (p. 1190)

15	Lanphear & Vandermaas-Peeler (2017) Inquiry and Intersubjectivity in a Reggio Emilia-Inspired Preschool Journal of Research in Childhood Education	Guided participation occurs as adults help children structure activity participation based on their development and bridge current and new understandings and skills (Rogoff, 1990; Vygotsky, 1978)_P.597) Inquiry-based guidance is one approach to guided participation that has been studied in early childhood educational settings as a way of encouraging children to explore the world around them (Ermeling, 2010; French, 2004; Gerde, Schachter, & Wasik, 2013; Inan et al., 2010). When adults employ inquiry guidance, they use open-ended questions to encourage children's inquisitiveness, exploration, and problem solving (Edwards, Gandini, & Forman, 2011) (p.597) Inan et al. (2010) examined the impact of inquiry-based guidance on science education in a preschool classroom and found that this approach led to children deeply engaging in activities and learning science process skills, such as hypothesizing and questioning (Inan et al., 2010). These findings were similarly observed in the classrooms studied by Ermeling (2010). In his study, teachers were taught to let children question and seek knowledge, rather than giving children all of the answers, which was shown to help the children better understand the material. Inquiry processes can include the seven steps of the scientific method: observation, asking questions, making hypotheses, experimenting, analysis and conclusion, communication, and asking new questions (Gerde et al., 2013). . A modified scientific method to study inquiry was used by French (2004), who grouped the inquiry processes into the four units of (1) reflect and ask, (2) plan and predict, (3) act and observe, and (4) report and reflect. This method, in conjunction with multiday projects, was shown to support children's engagement in higher order cognitive skills, such as predicting and reflecting. Gerde et al. (2013) stated that inquiry as a lens of learning carries beyond science experiences and leads children to explore and question in other activities, such as group play and outdoor time (p. 597-58)
16	Leonard, Boakes, & Moore (2009) Conducting Science Inquiry in Primary Classrooms: Case Studies of Two Preservice	describe inquiry as "authentic questions generated from students' experiences" (p. 21). The NSES further assert that When engaging in inquiry, students describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. In this way, students' activity develops their understanding of science by combining science knowledge with reasoning and thinking skills. (p. 27)

	Teachers' Inquiry-Based Practices Journal of Elementary Science Education	Drawn from the tenets of constructivist learning theory (Eick & Reed, 2002), inquiry has been characterized as both an orientation (i.e., nature of science) and a process (i.e., method of science) (Bianchini & Colburn, 2000). Lambert (2007) describes the processes “as knowing, inferring, analyzing, judging, hypothesizing, generalizing, predicting, and decision-making” (p. 389). The scientific method allows students to identify the problem, formulate a hypothesis, design an investigation, make and record observations, interpret data, and explain the results (Crawford, 2007; NRC, 1996). Bodzin and Beerer (2003) used the processes of science to develop the Science Teacher Inquiry Rubric (STIR). The STIR can be used to rate inquiry-based practices across six categories (those categories are explained later). We used these categories to obtain process data on the inquiry-based practices of prospective teachers in their first year of the study. In practice, Windschitl (2003) describes four types of science inquiry: (1) confirmation experiences or “cookbook labs” that are used to verify a known fact, (2) structured inquiry through which students are given the question and procedure to discover an unknown answer, (3) guided inquiry through which teachers allow students to investigate a prescribed problem using their own methods, and (4) open inquiry through which students form their own questions and conduct independent investigations (p. 114). (P.128)
17	Leuchter, Saalbach, & Hardy (2014) Designing Science Learning in the First Years of Schooling. An Intervention Study with Sequenced Learning Material on the Topic of "Floating and Sinking" International Journal of Science Education	inquiry-based instruction (understood as hands-on activities within small groups and with sense-making discussions) is expected to enhance both scientific content knowledge and scientific inquiry (National Research Council, 1996). On the other hand, current science education theories promote the importance of structuring and scaffolding as a standard of science instruction (Kirschner, Sweller, & Clark, 2006). Matching the two, inquirybased instruction along with scaffolding, seems to be most suitable for young children (Furtak, Seidel, Iverson, & Briggs, 2012; Hardy et al., 2006; Trundle & Sac¸kes, 2012). While there is some research with regard to instructional conditions and accompanying early childhood teaching (Appleton, 2008), the age at which an early science learning progression may be successfully implemented is often not specified._(p.1751) Inquiry based instruction has to take into account that on the one hand, open inquiry environments may be unproductive, especially for young learners with low self-regulation capacities and persistent misconceptions but on the other hand, traditional forms of instruction often fail in achieving students’ long-term conceptual restructuring with regard to basic science concepts (Duit & Treagust, 2003; Holliday, 2006) (p.1755) In the following, we propose two main foci for designing a curriculum for early science learning, intended to support conceptual restructuring by means of scaffolding student learning in an inquiry-based setting: (a)

		using structured task features to support reasoning with the targeted concepts and (b) embedding scientific reasoning in a three-step process of inquiry that allows the students to increasingly take responsibility for their own learning. Scaffolds in terms of task features. Instructionally sensitive tasks and materials need to incorporate aspects of a conceptual progression in order to ensure children's effective engagement with the learning content. How could this be done? Young children's explanations of objects' floating or sinking usually involve misconceptions such as a focus on salient features (e.g. shape, weight, or size). Accordingly, tasks targeting conceptual restructuring need to both challenge children's intuitive theories and have them take into account new properties, in this case material kind, for their predictions of objects' floating or sinking. This can be supported by establishing structural similarities across same-material objects both verbally and non-verbally. Structural similarities function as an 'invitation for comparison' which has been shown to be an important process with regard to conceptual development (Namy & Gentner, 2002). Thus, presenting structural similarities may stimulate children to compare objects with each other, to ask investigative questions about objects' behavior in water, to form educated expectations. With further scaffolding, children may also be led, to conduct simple investigations and to observe results, to justify an argument, and to discuss alternative ideas (Bybee, 2006; Mo¨ller et al., 2012). As Wiser and Smith (2008) pointed out: 'Using "plastic" as an adjective guides generalization across different kinds of plastic objects and thus encourages linking 'plastic' to shininess, lightness, and flexibility' (p. 209). Also grammatical construction such as 'This is made of plastic' or 'This is plastic' as opposed to 'This is a cup' draws children's attention to the material dimension. Furthermore, hands-on experiences help children to detect similarities in appearance and behavior across objects of the same material. Thus, for example, in a task concerning floating and sinking, children could consider solid objects which differ in shape, weight, or size but which consist of the same material when predicting their floating or sinking in water. Scaffolds in terms of a problem-based context. Putting the scientific tasks in a problembased context of scientific inquiry may be a further scaffold for conceptual development (Dewey,1910;Hmelo-Silver,2006).Authentic and complex problem settings inpersonally meaningful contexts (Pintrich, Marx, & Boyle, 1993) allow for multi-perspectives' approaches and multiple solution paths or solutions (Mayer & Wittrock, 2006), thus giving opportunities for scientific inquiry and conceptual restructuring (Linn & Eylon, 2006). A meaningful, contextualized, and complex problem for young children might be to find out which objects will float and whether, and if so, how floating objects can be made to sink. According to Holliday (2006), teachers should avoid what often can be observed: neither is it productive to guide a child step-by-step through tasks which

		learners are initially unable to place into a broader context nor is it fruitful to leave the children unsupported in their inquiry process (Appleton, 2008). Organizing the learning process as a three-step structure (Atkin & Karplus, 1962; Schiefele & Pekrun, 1996) should ensure that the intended problem-solving processes and patterns are indeed stimulated and can be carried out even by young children as self-reliant learners (Hiemstra, 2000). The three-step structure summarizes the Biological Sciences Curriculum Study (BSCS) 5E instructional model (Engagement, Exploration, Explanation, Elaboration, and Evaluation, Bybee et al., 2006) and considers the learning conditions of young children. In the preparation phase, teachers arouse children's engagement and motivation by introducing material that is appropriate in a domain and for a specific age group. Concerning young children, tasks and task introduction should always take into account their domain-specific knowledge (see above) as well as their domain general learning capabilities such as their natural curiosity concerning science (Conezio & French, 2002) and their limited executive functions (Garon, Bryson, & Smith, 2008). In the operation phase, teachers encourage the children to explore by generating questions and hypotheses and trying out different solution paths and explanations. During children's work, teachers adaptively support the learning processes by explaining and elaborating through modeling solution strategies and providing fading aids for carrying out solution plans (Lepper, Drake, & O'Donnell-Johnson, 1997). In the reflection phase, teachers support the children to explain and to examine each others' solution paths and detecting alternative ways of thinking (Kuhn, 2009). Teachers also evaluate learning outcomes and frame mistakes as opportunities for learning as well as plan next learning opportunities (Kloos & Van Orden, 2005). (p. 1755)
18	MacDonald & Breunig (2018) Back to the "Garten": Ontario Kindergarteners Learn and Grow through Schoolyard Pedagogy Journal of Outdoor and Environmental Education	Experiential education is often oversimplified as learning by doing^ (Breunig 2008; Roberts 2011). John Dewey is often regarded as one of the founders of experiential education. Dewey believed that subject matter should not be learned in isolation and emphasized the important role of the local community and out-of-classroom(p.134) Experiential education embraces transdisciplinary learning experiences to create and recreate knowledge as part of the educative process. Transdisciplinary experiential education extends beyond the commonplace reference to hands on^ learning activities (i.e. field trips or internships) to include problem-based learning, project-based learning, inquiry-based learning, community-academic partnerships, and student-directed learning, among other transdisciplinary pedagogies (Breunig 2017). (p. 134) One transdisciplinary, classroom-based platform for student-centred experiential education that acknowledges the relationship between individuals and their social and natural environments is inquiry-

		based learning (Gordon 2009; Savery2006). Inquiry-based learning specifically involves the open-ended investigation into students' intuitive queries with teachers serving as provocateurs in moving students forward in their own inquiries (Ontario Ministry of Education 2013). In viewing children as knowledge-possessing and capable of critical engagement in their own lives, inquiry-based learning places a focus on children's own questions, observations and interpretations of the world around them as a primary method of instruction (Fielding 2012; Savery 2006).(p. 136) typical of experiential, inquiry-based learning, which is student-centered and involves questioning, gathering information, and discussing and reflecting on ideas to generate new knowledge (Breunig 2013; Savery 2006). (p.142)
19	Margett & Witherington (2011) The Nature of Preschoolers' Concept of Living and Artificial Objects Child Development	Preschoolers and adults (supplying a baseline for comparison) who participated in this study were asked to complete a total of three phases. Each phase involved both groups viewing dynamic images of objects—both plants and animals, mobile artifacts, and immobile artifacts—and being given the opportunity to both ask questions (Phase 1) and answer questions (Phases 2 and 3) about the objects they viewed. (p.2069) In Phase 1, we predicted, by examining preschoolers' questions and statements made about objects, confirmation of previous results (Greif et al., 2006) such that preschoolers, like adults, should hold different expectations about the type of information important for categorizing novel animals and inanimate artifacts. We also predicted that these information-seeking differences in preschoolers would appropriately extend, as with adults, to plants and mobile artifacts, given that this method arguably targets a more implicit awareness of the Living–nonliving kinds distinction by not relying on preschoolers' explicit verbalization of this distinction. That is, preschoolers would want to know what an unfamiliar mobile artifact is used for yet would want to know about category membership, food choices, and typical locations for plants. Similarly, in Phase 2, we predicted, by examining what properties preschoolers attributed to the different objects, that we would confirm previous results (Backscheider et al., 1993; Inagaki & Hatano, 2002; Keil, 1992; Opfer & Gelman, 2001; Opfer & Siegler, 2004) such that preschoolers, like adults, would correctly distinguish living and nonliving kinds by selectively applying biological properties to animals and plants but not to mobile and immobile artifacts. In Phase 3, we targeted preschoolers' and adults' application of the concept ''alive'' to our four classes of stimuli and expected to confirm previous results that preschoolers, like adults, would overwhelmingly classify animals as living and immobile objects as nonliving (Opfer & Siegler, 2004). However, we predicted that preschoolers, in contrast to adults, would encounter more difficulty correctly

		assigning the word alive to plants but not to mobile artifacts (Carey, 1985; Hatano et al., 1993; Meunier & Cordier, 2004; Opfer & Siegler, 2004; Richards & Siegler, 1984; Waxman, 2005). (P. 2070)
20	McNerney & Hall (2017) Developing a Framework of Scientific Enquiry in Early Childhood: An Action Research Project to Support Staff Development and Improve Science Teaching Early Child Development and Care	to conceptualise science teaching in our setting: exploration, observation, interpretation (making sense) and mediation (guiding)._(207) Exploration With no prescribed content for science, and with an emphasis on learning through play, early years teachers in England can allow children both the opportunity and time to explore their environment, which is a natural component of children's play (Farmery, 2002; Howe & Davies, 2005). Exploration requires children to be actively engaged in their environment, taking risks to explore the unknown, asking questions and being interested in, and learning from, new experiences. This kind of exploration enables children to question why things happen and to start to make inferences as a result (Schulz, 2012). Through exploration of objects, children can explore how they work: what does it do? and how they might exert influence: what can I do with it? (Bjorklund & Gardiner, 2011, p. 154). Exploration of the world is, therefore, at the heart of scientific enquiry for young children. Through their exploratory play, children can develop scientific concepts, knowledge and skills (Johnston, 2005). For example, through water play, children can explore concepts such as buoyancy, finding out, through classification, which items will float or sink. Observation To be effective explorers, it is logical to expect children to have keen observation skills. Observation has been recognised as a vital skill for early childhood science learning (deBóo, 2006; Harlen, 2000). Children are natural observers and learn much from watching and copying others as well as when actively exploring on their own or collaboratively. These everyday observations help them to understand the world around them (Rogoff, 2003). However, for the purpose of science learning, Johnston (2005) pointed out that observation should go beyond just seeing: it should involve all senses and be used to identify similarities, differences, patterns and sequences in the environment. In other words, everyday observation involves noticing and describing the world, but scientific observation involves interpretation. For example, in exploring sounds made by different containers, children should be encouraged to look, touch and listen, and, in the process, be supported to interpret their observations: Do similar objects make the same sound? Which objects make the quiete stor loudest sound? Interpretation and mediation Interpretation, that is, sense-making, is also highlighted in the statement about science from EYFS. For scientific thinking to develop through children's exploratory play and observations, children should, at some stage, be able to interpret and make sense of their experiences so that they can gain a better understanding of the world around them. This, in our view, is a key component of science inthe early years in our setting:

		developing enquiring minds and scientific thinking to enable children to interact with and understand their environment. Whilst we explained previously that early childhood teachers tend to view science as a body of knowledge, children can learn scientific concepts and gain new knowledge through exploring their world (Kallery, 2004), with the caveat being that exploration is the starting point. As Bruner conceptualised, the aim of education is to promote enquiry and skill in the process of knowledge production, rather than memorise a body of knowledge: 'Knowing is a process, not a product' (Bruner, 1966, p. 72). An important point to make is that the theory that children will spontaneously 'discover' scientific concepts whilst exploring and observing for themselves is questionable(Harlen,2000),and the role of the teacher is vital in facilitating young children's development in science (Blake & Howitt, 2012; Harlen, 1999; Johnston, 2009). As Howe and Davies (2005) explain, young children's learning in science builds on prior knowledge through social interaction. Black and Hughes (2003) and Lemke (2001) concur and stress the vital role that language plays in co-constructing ideas about science and understanding the world. This suggests that science learning for young children is contextualised, bound by their prior knowledge and the socially constructed knowledge that develops through their interactions with the people around them. In assisting children to make sense and interpret the world around them as a result of their explorations and observations, teachers are required to mediate children through this process. This active role for teachers resonates with Vygotskian sociocultural theory in which adults or moreable peers mediate children's learning to enable them to reach levels of understanding that they could not reach alone (Vygotsky, 1978, 1986). To this aim, Howe and Davies (2005) claim that all exploration within early childhood settings should be carefully planned by the practitioner and suggest that even apparently 'free' exploration by children should be part of an intentional sequence of activities designed by teachers to develop children's scientific thinking.However,they c aution that the role of the adult within children's exploration is not always direct and should vary from observation of and/or playing alongside child-initiated exploration; intervening at key times to question and suggest ways forward and initiating activities for the deliberate development of specific scientific thinking (p. 159). The balance of knowing not just when, but how to interact and intervene in children's exploration is a significant and nuanced skill on behalf of the teacher. Knowing when to intervene is a pedagogic skill that covers all aspects of children's learning and is the focus of most preservice training. Addressing how to interact with children's exploration in science, as discussed previously, is not an area of strength for early childhood teachers. How to interact in science teaching is the

		central premise of this paper in order to provide a framework that all staff can use to assist in the development of scientific enquiry with young children. (p.207)
21	Merritt, Chiu, Peters-Burton, & Bell (2018) Teachers' Integration of Scientific and Engineering Practices in Primary Classrooms Research in Science Education	In this paper, we focus primarily on scientific and engineering practices, which build from NSES science as inquiry standards. They incorporate engineering problems and focus more on the importance of developing and using models than prior standards. They include asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing andinterpretingdata,using mathematicsandcomputational thinking, constructing explanations and designing solutions, engaging in argument from evidence and obtaining, and evaluating and communicating information (p.1323). Other practices, such as supporting claims with evidence and analyzing data, are less frequently observed in primary classrooms (Fulp, 2002; Trygstad et al., 2013) (p. 1323)
22	Metz (2008) Narrowing the Gulf between the Practices of Science and the Elementary School Science Classroom Elementary School Journal	Science educators and policy makers are increasingly calling for students not simply to learn science content, but also to do science (AmericanAssociationfortheAd- vancement ofScience[AAAS],1993;Na- tional ResearchCouncil[NRC],1996,2000). In thisvein,thenewNationalAcademyof Science reportonK–8science, *Taking Sci- ence toSchool,* emphasizes thefundamental importance ofengagingchildreninthe knowledge-building practicesofscience (Duschl, Schweingruber,&Shouse,2007). (p. 138) Features of the Practice of Science I conceptualize the nature of the scientific knowledge-building practices that are strategic and feasible to more adequately reflect in the elementary school science classroomintermsofseveninterrelatedfeatures of the practiceThree of the features concern the interface of content and process: (a) immersion within strategically selected scientific domains; (b) centrality of big ideas in the practices; and (c) entwining of content and process.The next three features concern issues of motivation and goal structure: (a) centrality of curiosity as a drive for the enterprise of science; (b) discovery and explanation as toplevel goals, processes such as observation and categorization function only as subgoals; and (c) the challenge and delight of structuring the ill-structured. The last is a single feature, albeit connected with all of those before: (a) the social nature of scientific knowledge building practices Discovery and Explanation as Top Level Goals, Processes Such as Observation and Categorization as Subgoals (p.140).

		The purpose of this initial scientific inquiry thought is epistemic, intended to introduce children to the enterprise of scientific inquiry while also serving as an early embedded assessment. I designed the thought experiment to fit Mayr's (1997) description of the most fundamental elements of inquiry: "an unexplained irregularity or anomaly" that arises from simple observation; a "puzzle" that emerges from this discovery; conjectures or hypotheses to explain the puzzle, and the testing thereof (145) inquiry consists simply of "making observations about the world, either looking carefully at things or trying to see what happens" (Driver et al., p. 141). ___
23	Metz (2011) Disentangling Robust Developmental Constraints from the Instructionally Mutable: Young Children's Epistemic Reasoning about a Study of Their Own Design Journal of the Learning Sciences	phenomenon-based reasoning" (p. 141). This initial level reflects a strong naïve realism: Inquiry consists simply of "making observations about the world, either looking carefully at things or trying to see what happens" (p. 141). Most of their secondary school students manifested the subsequent relation-based reasoning level, in which, in a significant step away from the phenomenology itself, inquiry is conceptualized in terms of relations between variables.However,Driveretal.'s finer grained specification of relation-based reasoning reflects multiple vestiges of a naïve realism; in particular, relations are framed in terms of observable features that are "taken-for-granted as existing in the material world" (p. 115) and students assume a one-to-one correspondence between material world and causal factor (p. 115). Only a small minority of their 16-year-olds exhibited model-based reasoning, conceptualizing inquiry in terms of models of "provisional status" that do not "arise directly from the data" but consist of "coherent stories" based on "posited theoretical entities" involving "imagination and conjecture." Consider the construct of "model." As elaborated in the theoretical and instructional design work of Lehrer and Schauble (2000), it has many forms: from physical models, representational models, or syntactic (or analogical) models to hypothetical-deductive models (p.53) These children had a strong motivation to be engaged in their investigations and subsequently the interview questions as they focused on the adequacy of their study as an instrument for addressing their question. (p.106) Making scientific inquiry accessible to young children constitutes a key chal lenge, particularly if one aims to avoid reducing the epistemic practice into the application of discrete science process skills. This instructional model sought to make inquiry accessible by manipulating the social unit responsible for the

		inquiry as well as the degree to which the inquiry was "well structured" versus "ill structured." The social context of the practice of science is fundamental to the power of scientists, supporting such functions as their generation of new ideas, critical examination of competing scientific interpretations or arguments, and taking on of investigations that would be beyond the reach of the scientist working alone (e.g., Dunbar, 1999; Latour, 1999; Okada & Simon, 1997). I aimed to capitalize on the supportive potential of working together in engineering children's practices in science. The instructional model manipulates the social unit responsible for the inquiry in order to adjust the cognitive load on the individual student, with the whole class working together with the teacher as the most supported unit and the pairs working largely independently as the most demanding. Much of the "inquiry" that students experience in school takes the form of all following the same recipe, a set of procedures implemented to reach a known result (Chinn & Malhotra, 2002). I view the challenge and delight in structuring the ill-structured as a key feature of scientific inquiry as practiced by scientists. Indeed, the enterprise of scientific inquiry epitomizes an "ill-structured problem" (Newell & Simon, 1972; Simon, 1986) in that how to think about the problem or go about solving it is not defined within the problem itself, nor is it transparent when the problem is "solved. (p. 61)
24	Monteira (2015) The Practice of Using Evidence in Kindergarten: The Role of Purposeful Observation Journal of Research in Science Teaching	In policy there has been a move toward situating scientific practices at the center of teaching and learning. This trend is consistent with a model that views science as consisting of a set of scientific practices (p.1233) Recent understandings of science view it as a set of scientific practices (Osborne, 2014). Osborne argues that science education needs to include explaining why we know what we know, for doing so will contribute to a commitment to evidence as the epistemic basis of beliefs. Policy reforms in the United States are aligned with this approach, adopting a focus on scientific practices alongside crosscutting concepts and core ideas as exemplified by the New Generation Science Standards (NGSS) (Achieve, 2013; NRC, 2012). The examination of the use of evidence is framed in this notion of scientific practices, as a part of practice 7 Engaging in argument from evidence (p. 1235)_ Most of the work about the use of evidence in primary and secondary classrooms is framed in the construction of explanations. Duschl’s (2008) Evidence-Explanation (E-E) continuum involves three critical transformations orstudents’judgments:(1) selecting or generatingd ata to become evidence;(2)using evidence to ascertain patterns of evidence and models; and (3) employing the models and patterns to propos explanations. As Duschl points out,each of the se transitions involves making epistemic judgments about

		"what counts" as data, evidence or explanations. however,our work with kindergarteners focuses on the first stages:articulating claims,selecting or generating data to become evidence,identifying patterns,andusingevidenceto support claims. (p. 1235) we are focusing first on this "what counts" as evidence dimension, in other words, data are considered evidence if their discursive role in children's talk is to evaluate a claim; and second, on the appropriateness of data to support the claim. (P. 1236) (1) selecting data appropriate for being transformed into evidence related to a claim; and (2) identifying potential (appropriate) evidence that could confirm or disconfirm a claim. Both processes would be scaffolded, as is the case in our study. (p.1254)
25	Peterson & French (2008) Supporting Young Children's Explanations through Inquiry Science in Preschool Early Childhood Research Quarterly	These skills are supported by the daily use of a science cycle, which is comprised of four steps: Step 1, Reflect and Ask, typically takes place during a Circle Time activity in which the teacher introduces the science topic for the day through a demonstration, discussion, and related fiction or non-fiction book reading. Step 2, Plan and Predict, occurs as the teacher introduces children to the science activity of the day and asks them to plan how they will conduct the activity and to predict the outcome. In Step 3, Act and Observe, children take part in small group science activities where they engage in hands-on exploration and manipulation. Teachers are encouraged to "wrap language around activities" to facilitate children's ability to map their mental representations of the science concepts onto language. Step 4, Report and Reflect, typically takes place at the end of the day, when children communicate their findings in the form of an experience chart, drawing, or verbal report. This structured science cycle allows the teacher to model and support children's use of the language and thinking processes associated with scientific inquiry. (p.397)
26	Philippou, Papademetri-Kachrimani, & Louca (2015) "The Exchange of Ideas Was Mutual, I Have to Say": Negotiating Researcher and Teacher "Roles" in an Early Years Educators' Professional	Learning was therefore seen as a socio-cognitive process, resembling that used by scientists in scientific communities, to pose questions and problems, formulate hypotheses, design, collect and analyse data, experiences and observations, formulate conclusions and construct or reconstruct theories. Within inquiry-based learning, emphasis may be placed on processes of investigation (for example, Gott and Duggan 1995, Etkina and Van Heuvelen 2007), problem-solving (for example, Blum and Niss 1991, Erickson 1999, Lubienski 1999) and modelling (for example, Constantinou 1999, English 2003, Lesh and Lehrer 2003, Louca and Zacharia 2012) as a means for supporting children to construct nuanced meanings of the world that surrounds them. (p.385)

	Development Programme on Inquiry-Based Mathematics and Science Learning	As children were now expected to engage with mathematics and science inquiry in epistemologically similar ways to those used by scientists, so were teachers engaged in this process, by inquiring and researching their own practice. This seemed to be strongly associated with a change in how they viewed children and teaching. (p. 392)
27	Roehrig, Dubosarsky, Mason, Carlson, & Murphy (2011) We Look More, Listen More, Notice More: Impact of Sustained Professional Development on Head Start Teachers' Inquiry-Based and Culturally-Relevant Science Teaching Practices Journal of Science Education and Technology	We specifically introduced The Young Scientist: Discovering Nature with Young Children Curriculum as it is designed to help young children develop important skills in science-inquiry, literacy and math and to introduce children to critical thinking skills such as questioning, investigating, discussing, and formulating ideas and theories. This constructivist curriculum guides teachers through the stages of open and focused explorations, emphasizing the value of students' ideas and prior experiences. The curriculum gives specific examples and discusses specific activities, so it would fit teachers who like to rely on structured manual, but it is also open enough so it would be a great resource for teachers who like to develop their own lesson plans and to integrate culturally specific science activities.(p.571) encourage hypothesizing, predicting, and higher-order thinking skills (Early et al. 2005; La Paro et al. 2004). Zech et al. (2000) also emphasized collaborative inquiry where content knowledge could be developed through the investigation of problems that originated in the classroom. (p.569) The sessions focused on skills like engaging children in open-ended questioning, allowing enough time for children to think and answer, asking for more than one correct answer and recording their observations (p.575) Such as questioning, investigating, discussing, and formulating ideas and theories. This constructivist curriculum guides teachers through the stages of open and focused explorations, emphasizing the value of students' ideas and prior experiences. (p. 571)

28	Samarapungavan, Mantzicopoulos, Patrick, & French (2009) The Development and Validation of the Science Learning Assessment (SLA): A Measure of Kindergarten Science Learning Journal of Advanced Academics	Understand science as a process of inquiry is based on asking questions and making predictions about the natural world • Understand the empirical basis of science: Scientific ideas are evaluated by their correspondence or fit to empirical evidence • Understand simple tools used to gather, record, analyze, and share data (p. 508)
29	Samarapungavan, Patrick, & Mantzicopoulos (2011) What Kindergarten Students Learn in Inquiry-Based Science Classrooms Cognition and Instruction	The SLP program of science instruction is grounded in design principles for inquiry-based pedagogy, as recommended by a national panel of experts and summarized by Duschl and Grandy(2008).These design principles include the integration of the cognitive (science concepts and scientific inference processes), epistemic (knowledge validation and evaluation), and social (understanding the sociocultural norms and practices of science) dimensions in extended inquiry units (p.418) there is a general agreement that science comprises sets of sociocultural practices that enable members of the scientific community toco-construct, evaluate, and revise shared knowledge. These scholars also agree that developing shared norms for representing and evaluating empirical data plays a key role in the epistemic regulation of science. (p.418) we regard science as the collective processes of articulating, testing, evaluating, and refining or revising models of the world.We posit that inquiry is shaped by the unique content of the specific models constructed in different disciplines including theoretical models,as well as data and investigation models(Chinn & Samarapungavan, 2008; Suppes, 1960, 1962; Woodward, 1989). SLP places no emphasis on students acquiring certain traditional vocabulary terms with regard to scientific inquiry such as “theories,” “laws,” or

		"hypotheses" in light of the ongoing debates about the meaning and utility of these terms in the history and philosophy of science (Cartwright, 1983, 1999; Giere, 1988; T. Kuhn, 1962; Laudan, 1990). As elaborated in prior publications, the SLP starts with the premise that science can be viewed as a community of practice that shares key cognitive resources such as problem spaces, representational conventions, and knowledge of important domain models, techniques for collecting and analyzing data, and epistemic norms and criteria for evaluating knowledge (Samarapungavan et al., 2008, 2009). (p. 428) A key feature of pre-inquiry activities is that they are designed to provide children with entry points into the processes of science learning by drawing on their everyday experiences and ideas. (p. 437) Post-inquiry activities typically consisted of whole class presentations and discussions in which children reviewed and shared what they had learned with each other (p.447)
30	Senocak, Samarapungavan, Aksoy, & Tosun (2013) A Study on Development of an Instrument to Determine Turkish Kindergarten Students' Understandings of Scientific Concepts and Scientific Inquiry Processes Educational Sciences: Theory and Practice	There are some studies on the limitations of empowering children's understandings of scientific inquiry processes (Metz, 2004; Samarapungavan et al., 2008; Zhang, Parker, Eberhardt, & Passalacqua, 2011). Many indicators reveal that children show interest in inquiry-based programs, and that they acquire the basic skills of the scientific process. Metz (2004) reported that parents whose children participated in an inquiry-based instruction stated that their children were interested in becoming a scientist. Eshach (2011, p. 442) said, "Children have sufficient cognitive capabilities to engage in scientific inquiry." Samarapungavan et al. (2008) administered a science learning program that was grounded in scientific inquiry and literacy activities. They collected data from both invention and comparison group kindergarten children by using different data collecting tools. Results showed that intervention group children had better scores than comparison group children with respect to acquiring the key aspects of scientific inquiry processes and science concepts taught in this program. Inquiry is a process that involves wondering, asking questions, collecting data, and answering questions in order to learn what is taking place around us. Inquiry is provoked by a sense of curiosity and is the powerful sense driving human beings to discover something of the world around them. Curiosity is the desire to learn or know about something (Harlan & Rivkin, 2008, p. 4). Barell (2008) stated that children are born with a sense of curiosity, and students at an early age can ask interesting and challenging questions to solve problems. He also suggested some effective activities to foster and keep children's curiosity such as keeping wonder journals, developing problematic scenarios, and garnering parental support. Furthermore, Rankin (2011) expressed that students' curiosity can be sustained

		with an effective pedagogical structure which can provide inquiry experiences. Inquiry requires some skills such as observation, questioning, measurement, classification, and prediction. These are known as the basic science processes (Bentley, Ebert, & Ebert, 2007; Martin, Sexton, Franklin, Gerlovich, & McElroy, 2009), and these are appropriate for kindergarten (Martin et al., 2009). In fact, we use these processes in our daily lives when trying to solve problems, even if we generally are not aware of using them. Nowadays, educators endeavor to develop new ways to keep children's scientific curiosity alive or take them much further. "A Nation at Risk Report" is one of the most obvious examples of these endeavors. In 1981, a commission was constituted to present a report on the quality of education in the United States. Almost two years later, the commission released a report named, "A Nation at Risk: The Imperative for Educational Reform". They examined the quality of teaching and learning in schools. In this report, there were some emphasizes on science education. For example, it was proposed to revise the science courses and recommended using the methods of scientific inquiry and reasoning to raise citizens who are literate in science and technology (A Nation at Risk, 1983). In the early 2000s, a strong effort was started in Turkey to revise and develop new curriculum to parallel the new trends in education. With this effort, the main idea in the curriculum has changed from the content-centered to the student-centered (Bulut, 2007), and it aimed to raise scientifically literate citizens (Bahar, 2006). Therefore, we included a second dimension in the instrument to reveal some clues to understanding the extent to which Turkish preschool students are aware of scientific inquiry processes. (p. 2219)
31	Siry, Ziegler, & Max (2012) Doing Science" through Discourse-in-Interaction: Young Children's Science Investigations at the Early Childhood Level Science Education	We emphasize the dialectical relationship between processes at individual and collective levels as central to interacting, learning, and co-constructing science, and we detail these perspectives further throughout the analytic discussion of data in later sections. (p. 313) For us,science is a human activity, one which comes into existence as it is done within interaction, whereby interactants are continually shaping, and are being shaped by, the activity and the constructed context through multiple situated interactions. Thus, science emerges from the "doing,"which includes physical processes and experiences as well as dialoaic interactions (Ash, 2004).We share an understanding that as science is done it is talked into being (Gallas, 1995; Lemke, 1990). The dialectical approach allows us to move beyond traditional static and linear models to work toward a depiction of the complexity of human interaction and experience that depicts social phenomena as"multiple systematically interacting elements"

		(Engeström & Miettinen,1999,p.9).Through these frameworks, science learning,thinking, and knowing are addressed within our study at an early moment of becoming a participant in "doing science. (p.313) When science becomes relevant within an interaction, participants will organize their general talk with regard to the more specific science object at hand. As such, they refer to and expand discourse practices, which pertain to the science-specific perspective emergent from the interaction (e.g., "just go on pouring, one might not be enough here and the second one has the same volume"). The organization of this science-related discourse-in interaction draws from,feeds into,and constitutes over time the larger Discourse as Science. More specifically, the science-related discourse-in-interaction systematically emerges from a science goal–orientated interaction. We argue that it is important to recognize that young children'sscience-related talk is not just alow-quality version of standardized ore stablished ways of science.Quite on the contrary,these discourse formats often precede(and are atthe origin of) the standardized canonical discourse formats (Schlieben-Lange, 1987), which function as norm orientation in the general landscape of science as practice and theory. (p.314) We conceptualize science as an emergent process: one that is generated by participants in the doing. We understand "doing science" within institutional settings "as learning to deal with locally organized and sequentially structured discourse activities, and hence rooted in the learner's participation in organizing talk in interaction, such as configuring participation structures or sequencing activities" (Pekarek-Doehler & Ziegler, 2007, p. 85). As discourse emerges from what the participants are doing, science is (continuously) emergent through interaction and discursive formats. Consequently, and over time, practices more strongly refer to established practices and are more easily acknowledged as being "science." This, however, does not imply that lesser normative practices "do science" to a more limited degree. Rather, informal science dialogue can become the basis for broader scientific literacy (Ash, 2004). (p. 314) 1. "Doing science" emerges from a goal-oriented activity that frames the children's actions. This mutual interaction creates a discourse of science. 2. Children make relevant their everyday ways of participating within their science related interaction practices.They use and modify other discourse formats from other goal-oriented activities that are familiar to them. 3. Children display an awareness of "doing science," as

		they collaboratively orient to a specific format for completing the activity. They enact discursive structures that reveal science within unfolding dialogue (p. 320).
32	Van Hook & Huziak-Clark (2008) Lift, Squeeze, Stretch, and Twist: Research-Based Inquiry Physics Experiences (RIPE) of Energy for Kindergartners Journal of Elementary Science Education	In developing this study, we followed recommendations in the literature, starting from personal experiences and having students begin young with simple real-life experiences with energy (Lijnse, 1990; Trumper, 1990). In previous studies (Van Hook, Huziak, & Nowak, 2005; Van Hook & Huziak-Clark, 2007b), kindergarten students were able to develop a basic conception of physics concepts (e.g., air and magnetism) when taught with inquirybased lessons that combine hands-on activities with class discussion, a simple conceptual model, succinct phrases (cognitive hooks) that capture key concepts, and reinforcement through multisensory activities. These elements of RIPE aid student learning when dealing with abstract concepts and new scientific vocabulary. This study of the early childhood RIPE model examines the effect of a set of lessons that provided kindergarten students with a range of experiences to help them begin to develop an understanding of energy. (p.3) the RIPE early childhood instructional model (developed by the authors) can be effective in teaching physics concepts to early childhood students. The RIPE model includes inquiry-based activities; learning cycle approach to instruction; multisensory activities such as kinesthetic movements, songs, and key concepts; and cognitive hooks to help students remember and apply knowledge. Key to this model is identifying a small set of core concepts and focusing intensely on them rather than trying to address many concepts in a unit. In addition, the concept is phrased in a manner that is as simple and concrete as possible and that is continually reinforced through brief phrases expressing interactions (not simply vocabulary words) that help students articulate scientific notions about a wide variety of experiences. These cognitive hooks, such as “lift,” “squeeze,” “stretch,” and “twist,” capture key scientific principles and yet are meaningful to students. The 5E model provides a powerful overall structure to the lessons, engaging students, allowing them to explore the concept, explaining the scientific concept, extending and reinforcing the concept, and evaluating the students’ understanding throughout. In the RIPE model, it is critical that the explanation of the scientific concept develops from a class discussion of the students’ ideas and observations, and does not devolve into a lecture about the concept by the teacher. (p.12)
33	Wastin & Han (2014)	Children can then use these investigative techniques that incorporate different subject areas and apply these skills to anything that interests them later on in life – something that drilling topics separately can never achieve. Their problem solving and critical thinking skills flourish with this approach. (p.3)

	Action Research and Project Approach: Journey of an Early Childhood Pre-Service Teacher and a Teacher Educator Networks: An Online Journal for Teacher Research	Phase 1. The purpose of Phase 1 is to identify the topic by having young investigators figure out what they want to know (Helm & Katz, 2011). Ideally, it is the children that initiate the project idea; however, due to the nature and time constraints of the mini project, I introduced the topic of rain based on the unit on weather. For Phase 1, we created a class web where I extracted their prior knowledge about rain and where it comes from. Afterwards, we explored three different books about rain and weather to expand our knowledge and gather more information. We then returned to the web and added to what we knew about rain (p.4) The purpose of Phase 2 is to investigate the topic with in-depth study of the questions posed in Phase 1 through hands-on experiences (Helm & Katz, 2011). In this phase, the children learned to gather data over a two-week span for our rain measure experiment, exploring mathematic skills. They also performed a rain simulation experiment and referenced secondary resources for more information working on scientific inquiry. The children continued to showcase their knowledge through reflective writings and discussions. (p.5) The purpose of Phase 3 is to wrap up the project in a culminating activity and to share with others what they have learned (Helm & Katz, 2011). (p.7)
34	Watts, Salehjee, & Essex (2017) But Is It Science? Early Child Development and Care	Through inquiry methods, the teaching of science aims to enable young children to obtain experiences that are authentic to scientific experience (Peters,2006) and this is thought to make their learning more meaningful and to improve their scientific understanding (Hogan,2000; Hogan & Maglienti, 2001). But, and it is a big 'but', Rop's(2002) work suggests that questioning – inquiry – is necessary but not sufficient: there need also be 'receptive contexts' for questions. When faced with an outpouring of questions, teachers and parents are actually ambivalent at best. They commonly listen to a child's open curiosity with contradictory feelings: the need to 'honour' the child's question, give her or him time and patient support in the struggle to understand content – all of which is then weighed against the seemingly incompatible need to maximize 'teaching time', 'cover the expectations of the school' and 'get on with things'. Even less compassionate is when teachers perceive a child's questions as annoying, 'going against the grain', an impediment, overbearing and a test of patience, particularly when these arrive too frequently, or seem set to challenge received 'common wisdom'. There are only so many times an adult can answer 'why' questions one after

		the other in rapid succession without losing patience or exhorting a greater power ('Because I say so!!'). These different teacher attitudes impact upon the ways questioning is encouraged or discouraged during school or nursery time. In reality, teachers are very concerned with such 'micro-politics' of ('real') classroom life. Recent work (e.g. Pedrosa de Jesus, Moreira, da Silva Lopes, & Watts, 2012) illustrates just how context-sensitive is the asking of questions. In this sense, a 'receptive context' is the set of entities that influence action in a particular setting, situation or on a specific occasion (Brezillon, 2003, 2005), in particular the 'physical, emotional, and intellectual environment that surrounds an experience and gives it meaning' (Caudron, 2000, p. 55). A 'positive, receptive, context for questioning' moves beyond usual practices in teaching; it is the prime criterion for building an environmentwhere children's classroom questions are the norm. Not all classroom contexts arepositive, and there are numerous instances where children's questions are dismissed, not welcomed, let alone acted on. (p. 276) Moreover, there are many types of questions, some that are answerable and many that are not (Watts & Pedrosa de Jesus, 2006). Of interest here is a mode of questioning that focuses on empirical work, those questions that can lead to investigation, experiment and some resolution. 'Investigable' questions (Chin & Kayalvizhi, 2002; Graesser & McMahen, 1993) require a particular form of construction. (p.276) 'But is it science?' through just three ingredients central to education in the early years: first, 'empirical question-asking'; second, 'transgressive play'; and third, 'good thinking' (p. 275) So,our tack is that inquiry-based learning, manifest within the three ingredients above, is vastly important not solely because it allows entry into science, but because it works powerfully well across different disciplines. Second, there are many more processes entailed within science that also need to be encouraged before it can appropriately be called science. (p.276) According to Chin and Kayalvizhi (2002) and Arnold (2009), a good investigative question requires learners to generate and collect data for a selected pathway; represent, analyse and interpret their findings using the data collected; draw a conclusion using their results and justify their findings to the question based on the data they have collected. Chin and Kayalvizhi (2002) further suggest that in order to fully engage children and sustain their interest, these questions should be conceptually challenging, meaningful and relevant to

		their personal experiences, while remaining broad enough to enable critical and creative thinking. Such challenging questions can spring from odd events, passing thoughts or conversations, a technological problem, some difficult results, a curious occurrence, a chance observation, a fascination with some particular area of life, a claim on a TV advert, a pet's habits, a family discussion, a sporting occasion, family obsessions or hobbies. That is, the processes of 'disequilibrium detection', of problem finding (Watts & Pedrosa de Jesus, 2010), come from children's interactions with life – and often from the clash between experience of 'life issues' and the overlay of knowledge derived from school and other informative sources throughout the early years(Watts&Alsop,1995).In some ways, this is a precurser to the Cognitive Acceleration in Science Education notion (for older children) of cognitive dissonance (McCormack, Finlayson, & McCloughlin, 2014). That said, Walsh and Sattes (2005) make the point that formulating investigative questions is a skill that needs to be explicitly taught in early years and beyond. Thornton and Bruton (2015) point to this kind of early-years inquiry as the 'Reggio Emilio approach', where children are encouraged to develop their own theories about the world and to explore these collaboratively in great depth. Strong value is placed on different experiences, ideas and opinions so that when a child stands at the centre of a paved playground after a heavy spate of rain and asks, 'Where does all the water go?' the child's ideas are respected and taken seriously, and are used as the start point of investigations. Thornton and Bruton say it is important to create an environment in which 'children are unafraid of making mistakes or of reconstructing their ideas' (2015, p. 17). The adult intervenes as little as possible but observes, listens, interprets and facilitates the child's inquiry by providing interesting experiences and resources. In this respect, there is no predetermined curriculum to determine what children must learn; the educational experience is generated on an ongoing basis from the questions, ideas and theories put forward by the children supported by the 'skills, expertise and experience of the educators working alongside them' (86) (p. 277)
35	Wu & Lin (2016) Inquiry-Based Mathematics Curriculum Design for Young Children-Teaching Experiment and Reflection	In addition, engaging children in the learning processes and providing inquiry-based learning opportunities were useful in enhancing their reasoning and problem-solving capabilities, which further furnished them with better understanding of mathematical concepts (Kennedy, 2009; National Council of Teachers of Mathematics [NCTM], 2000). (p. 844) The early learning experience could positively stimulate and enhance young children's potential for exploring the world in the future. • The function of inquiry teaching is to organize activities based on the

	EURASIA Journal of Mathematics, Science & Technology Education	purpose of discovering problems or creating cognitive conflict scenarios. • Meaningful learning of mathematics was to provide enriched mathematical learning experiences where children could be meaningfully guided to discover the structural relationships between concepts connected with numbers and their applications to problems arising from the real world (p. 844) Additionally, an inquiry-based approach is seen as vital for children to obtain scientific content knowledge through the problem-solving processes (National Research Council [NRC], 2000), which includes identification of assumptions and use of critical and logical thinking, as well as consideration of alternative explanations (NRC, 1996). Based on a philosophy of mathematics education, Richards (1991) described inquiry as learning to speak and act mathematically by engaging in mathematical discussions, proposing conjectures, and solving new or unfamiliar problems. Further, Yackel et al. (1990) claimed that children's mathematical knowledge could not be delivered simply from one teacher's instruction but must develop from participation in inquiry-based learning activities instead. Within this participative learning process, children were expected to comprehend what they saw and/or heard and bring up their own explanations. In short, inquiry-based mathematical instruction emphasizes a child-centered approach of "autonomy and manipulation", where children can discover and solve the problems firsthand. This instructional approach also offers teachers abundant opportunities to observe their kids' mathematical opinions and further bridge them toward a path of higher-level mathematical development. (p. 844) The focus of inquiry teaching is to organize learning activities on the basis of discovering problems or creating cognitive conflict scenarios, which then provide young children with various opportunities for discovering scientific problems and developing the capability of using critical thinking while working on tasks and constructing problem-solving solutions (NRC, 2012). Thus, every child's role is that of an enthusiastic thinker, actively engaging in the process of questioning, observing, categorizing, explaining, applying, developing, and expressing their own opinions while accepting those of others, with the ultimate goal of being capable of solving problems and understanding their rationale (NRC, 1996; 2012). In this study, we employed the 5E Instructional Model (Bybee et al., 2006) in designing the inquirybased learning activities of the targeted curriculum, including five phases (an inquirybased learning cycle): engagement, exploration, explanation, elaboration, and evaluation. Based on constructivism, this model provides a basis for teachers to use diverse teaching strategies to advance their children's active learning (Bybee, 1997). By

		building up an inquiry learning environment, children can both explore and explain what they have learned (Orgill, & Thomas, 2007), as well as detect and solve life-related problems in their own ways (Chang & Wu, 2015). (p. 846) With this approach, children's learning processes were not "try and error" attempts but the systematic learning of problemsolving in a meaningful context. Moreover, according to the tenets of Constructivism, the learner constructs his/her own understanding through experience; "problematic experience can initiate the learning process and subsequent experiences lead to changes in understanding and action" (Osterman, 1998, p. 4). As a result of interactions between new and past experiences, authentic learning of a new concept is constructed. Therefore, learning is an active process requiring children's engagement. In the teaching of mathematics, teachers need to create an enriched learning environment full of life experiences and meaningful contexts; this precept was fully applied in our design. (p. 846) In relation to the constructivity principle, it was suggested that teachers design hands-on activities with the use of realistic and concrete objects (manipulatives) whereby kids can be stimulated both physically and mentally to sense the structural relationships firsthand. (p. 846). In summary, in this project, Dienes's (1973) theory of learning mathematics was applied in designing the targeted curriculum for children, ages 3-6, in which an inquiry-based instructional approach was employed. The model was based on his six stages of learning mathematics. "Free experiments" and "comparison" were merged as a "problem solving" procedure. "Representation" and "symbolization" were integrated for stimulating children's expression and communication. The result was that we developed a "four-stage developmental model" for structuring sequential learning procedures in every lesson: (1) free play: exploring problems; (2) exercising your brain: problem solving; (3) s/he, you, and I: expression and communication; and (4) just doing it: integrated inquiry (p. 847) Mathematical teaching procedures 5E inquiry-based learning cycle Constructing learning contexts and free play Engagement Choosing and initiating inquiry-based activity Engagement, exploration Posing and deciding exploratory question(s) Exploration Planning and executing problem-solving method(s) Exploration Observing cognitive behaviors Explanation Designing an activity which causes cognitive

		conflict(s) Explanation Concluding experiences of inquiry-based activity Elaboration, evaluation Providing resembling and/or extending activities Evaluation (p. 848)