Saima Salehjee, School of Education, University of Strathclyde.

Teaching science through stories: mounting scientific enquiry

Introduction

Early years and primary children are highly competent and capable enquirers trying to understand the world through curiosity, imagination and play (Blake and Howitt, 2015). Similarly, Nespor (1998) views this broad age group as 'young researchers'; Cremin et al. (2015) see them as 'creative little scientists'; D'Arcangelo (2000) refers to them as 'scientists in the crib'. These capabilities of children are quite noticeable for example, Aslan, who is eight months old, he wanted to slide a plastic lid on a carpet in the same way he slides it on the hard wooden floor. It is an enjoyable experience for him, he can slide it from one side of the room to another. However, with multiple failures on the carpet, he started to slide the lid on shiny hard surfaces, working tops, fridge doors, metal bin and even the rough radiator surface. His curious nature helped him to learn about different surface textures and the rate at which things could slide. Sarah, at seven months, declines to use a store-bought toy mobile phone and, after comparing and contrasting the weight, size, colour, texture, light and music always craves her mother's very expensive iPhone. Milly, fourteen months old, loves puddles. She investigates these by touching, tasting and smelling - she now tries to make artificial puddle in her garden with soil and water, in the kitchen with flour, custard powder and milk, in school with Playdough and 'slime', she is continually testing different materials that, more or less, looks like a puddle but taste, smell and feel different. These young children are self-curious, exhibiting the development of enquiry skills, anxious to learn about the environment, trying to mimic their elders and exhibit a capacity to build their learning further through adults support (such as parents, siblings, peers, teachers), media, nature, society and culture (Lloyd et al., 2017).

The question is how we can strengthen this scientific enquiry among children from early year's foundation stage (EYFS) with an aspiration to develop further over time? So that, Aslan, Milly and Sarah and many other children like them, not necessarily will become practising scientists in the future, but it is hoped that these children will adapt a scientific attitude. An attitude that is valuable for them as individuals, community and to the society - by utilising scientific enquiry based skills (practices) towards becoming a problem solver and exhibit ability to apply these practices in the daily life contexts. This idea of developing scientific attitude is depicted from the notion of producing 'scientifically literate citizens', in various studies the production of producing scientifically literate citizens is viewed as a requirement, however, it is not quite evident widely in the society (for example: OECD, 2012; Holbrook and Rannikmae, 2009; Lee et al., 2013; Chin et al., 2016 etc.). Somewhere along the line from childhood to young adulthood, people cease to link, appreciate, apply and evaluate scientific knowledge (for example Murphy and Beggs, 2005, Archer et al., 2014, Salehjee and Watts, 2015). One of the suggestions, to overcome this issue to produce scientifically literate citizens, is by rooting scientific enquiry processes, as part of day-to-day teaching and learning practices (Zeidler et al., 2002). In doing that there is need for better scaffolding, where the role of practitioners, educators and teachers are seen as vital, in scaffolding prior understanding, beliefs and values on scientific knowledge and understanding of the world-view through science to nourish and develop scientific attitude among children (Ault & Doddick, 2010; Clough, 2006).

This paper will aim to present (i) a model of enquiry based learning to incorporate scientific enquiry ingrained in day-to-day teaching and learning practices, (ii) benefits of using stories to scaffold the process of scientific enquiry and (iii) some practical examples entailing stories as a platform to incorporate scientific enquiry skills.

Early years and scientific enquiry

Looking at the early years science curriculum in English schools is subsumed within the specific area of 'understanding the world', aimed towards 'guiding children to make sense of their physical world and their community through opportunities to explore, observe and find out about people, places, technology and the environment' (DfE, 2017, p.8). The three key indicators within the description which subsumed scientific enquiry within this specific area include the physical world, people and community and technology. In the primary curriculum 'working scientifically' entails a similar key position on scientific enquiry processes including (i) observation, (ii) looking for patterns, (iii) identifying, classifying and grouping different objects, (iv) performing simple tests, (v) compare and classify, (vi) asking simple questions, (vii) suggesting answers (DfE, 2015).

However, Rogers (2012) has argued that scientific enquiry processes in early years need further embedding within the programme, and science teaching and learning should be given a higher status, equalling that of literacy and numeracy. Similarly, in the most recent Ofsted inspection 2016/2017 report, *'Bold beginnings'*, it is recommended that science is an essential area of study along with English, mathematics and humanities, and that provision of science should start at the reception level or even earlier. In addition, Cermin et al. (2015) have recommended that there is a need in the early years and in the primary curriculum to incorporate further curiosity, along with enhancing scientific practical skills by developing,

> curriculum specifications that continue to prioritise the development of knowledge and understanding, skills and attitudes associated with inquiry alongside the development of concepts and give greater recognition of the critical roles of affective and social factors in learning' (p. 43).

It is quite noticeable in the literature on early years and primary teaching and learning that teachers, practioners and immediate adults play a vital role in further development of these curious minds (for example: Daniel, 2016; Devi et al., 2018; Howe et al. 2015). Out of which, many people make the point, however, that teaching and learning of science is not sufficiently effective in scaffolding children towards making them scientifically literate enquirers for the future (for example Harlen, 2017; Department for Education (DfE), 2012; OECD, 2009). Harlen and Holroyd (1997), around 22 years back, indicated that ineffective scaffolding by the early years and primary teachers' link strongly with their lack of confidence and self-ability in teaching science. Even in recent literature, the lack of confidence associated with lack of self-efficacy belief is evident among early years and primary teachers (Van Aalderen-Smeets et al. 2012) portraying teachers' weak pedagogical grounds (Peacock et al., 2017) - largely because they lack both science specialisms (Kambouri, 2016) and an understanding of the scientific enquiry skill development indicated in the curriculum (Lederman, 2013; Water-Adams, 2006; Trumbull, 2006). This results in teachers emphasising instructional modes of teaching instead of using relevant daily life examples in linking content knowledge to the larger world, to people and society (Genter and Colhoun, 2008). Resulting in producing a new generation of 'unthinkable' citizens rather than scenically literate and scientifically aspired citizens (DeWitt et al., 2013).

Enquiry based learning (EBL) and scientific enquiry

So how can scientific enquiry that teachers are failing to grasp, be embedded into the science curriculum? One of the recommendations is to introduce Enquiry Based Learning (EBL) approach, and, the 2013 survey of primary schools by the Office for Standards in Education (Ofsted), showed concern for the lack of EBL in schools, and strongly recommended an increase in the amount of science lesson time to incorporate scientific enquiry. The European Commission (2007) also indicated the need for scientific enquiry provision and highlighted the importance of EBL. Moreover, DfE's (2015) framework indicated six steps to achieve scientific enquiry under the umbrella term of 'working scientifically', a few educators have adapted this framework in early years and primary school settings. National Science Education Standards in the US termed it as science process skills that support teaching scientific skills (Haury, 2002).

In addition, EBL emphasises that imagination and exploration of the environment act as a starting point towards the development of scientific enquiry skills (de Boo, 2000). Similarly, Dockett and Fleer

(2002) use the word 'incidental science', where children learn about science in an incidental and playful manner, where an emergent curriculum arises from the child's own explorations and investigations; through guidance approach and scaffolding (Campbell & Chealuck, 2015). Similarly, John Dewey's early 20th century edict was that 'education begins with the curiosity of the learner' (Savery, 2015, p. 11) – first, science by doing and, second, through reflection (Kuhlthau, Maniotes and Caspari, 2015). EBL is independent student-centred learning that involves 'any process of learning through inquiry [enquiry]' (Hutchings 2007, p. 11) and the emphasis is on asking children to work as scientists designing, testing and critically concluding their results, rather than presenting the correct answers/results (Hepworth and Walton, 2009). For example teachers asking EYFS children to find patterns to observe, test and critically evaluate relationship: among (for example) constellations of stars, in cloud formations, in flowers growing on a hill compared to those growing on a flat surface, patterns among soapy bubbles, a layer of froth on expresso coffee and similar visual layers in oceans.

A number of studies are in place which indicates the use of EBL approach to stimulate scientific enquiry skills in children. For example, Minner et al. (2010) conducted a longitudinal study on enquiry-based science instructions impact on children (from 1984 to 2002) and reported that an 'investigation cycle' ('generating questions, designing experiments, collecting data, drawing conclusions, and communicating findings') and 'hands on experience' stimulated children's active thinking skills and, in turn, enhanced 'content learning, especially learning scientific concepts' (p. 20). Bybee, et al. (2006) highlighted the five Es (Engagement, Exploration, Explanation, Elaboration, and Evaluation) cycle; Eisenkraft (2003) extended the 5E model to the 7E model.

Recently, Pedaste et al. (2015), summarised existing EBL phases, after conducting a literature review on thirty-two EBL linked research papers, using the EBSCO host Library; which dealt with either describing particular enquiry stage or entire enquiry cycles. After reviewing these papers, they presented five main enquiry phases summarizing the key points of the reviewed articles. The five phases are as follows:

1. 'Orientation' phase where teacher's aim is to give learners food for thought. Similarly, Bybee et al. (2006) use the word engage to capture students attention, similarly, Eisenkraft (2003) believes that the component to engage involves making children enthusiastic, and ready to learn
2. 'Conceptualisation' phase links to Eisenkraft (2003) the second part of the engagement, that is, bringing in pre-held knowledge entailing 'elicitation' (Eisenkraft, 2003) and 'prediction' (Campbell and Chealuck 2015) with an emphasis to utilise this prior knowledge, generating simple questions or hypothesis. Likewise, DfE (2015) highlights the importance of eliciting children to 'ask simple questions' and recommended that effective support from teachers is needed to help children in formulating simple questions as enquirers
3. 'Investigation' phase is to allow students to find answers to their questions by making observations using senses, followed by selecting simple tools/equipments which they consider can offer an answer to their questions, performing simple tests and recording data (DfE, 2015, Campbell and Chealuck, 2015)
4. 'Conclusion' entail inferring, that is, suggesting answers along with reasonable explanations of the results gained from the investigation phase (Minner, 2010; Eisenkraft, 2003)
5. 'Discussion' phase involve children to communicate their conclusions by elaborating and reflecting their conclusions. Osborne (2014) gives special importance to this phase of the EBL cycle because he believes that scientists continuously evaluate their understanding of a phenomenon in the light of research and findings

Figure EBL and scientific enquiry processes

These five steps, act as a logically assigned set of smaller units 'that guide children and draw attention to important features of scientific thinking' and the co-ordination of these units constitute an enquiry cycle (Pedaste et al., 2015, p. 48). Therefore, it can be repeated as a cycle, many times, with a different variable in order to build in comparing and classifying aspects (Campbell and Chealuck, 2015) among and between each variable- as multiple phases.

EBL contributors give importance to the delivery of these phases in the classrooms to overcome, the above mentioned, issues of instructional and unthinkable science teaching and learning. As it implies various ways of 'open enquiry', where teacher's enquiry instructions could be guided yet not 'closed' (Justice, et al., 2002; Australian Academy of Science, 2013). Open enquiry involves children in generating questions, designing methods and drawing conclusion(s) themselves - closed enquiry involves only the teachers. In essence, enquiry-based processes and guided-enquiry is a combination of both student- and teacher-led participation. This mode of enquiry is seen to be suitable in primary science because closed enquiry involving step-by-step instructions, along with teacher led content knowledge, and is seen to hinder the 'development of children as independent and inquisitive young scientists' (Ofsted, 2013, p. 13)

Children stories and scientific enquiry

In terms of enquiry instructions at early years and primary stages, various teaching and learning approaches are evident in the literature, like learning through play (Cremin et al., 2015; Craft, 2002), outside learning (Coll, and Treagust, 2018; Jensen et al., 2015) and independent learning (Egan, 2009, 2010, 2013). Each of these approaches has shown to have benefits, in this article the focus will be to make use of children's stories as a teaching and learning tool, combining everyday science and scientific enquiry processes. Because, storytelling has a long tradition in helping children to learn about good and bad, hatred and affection and offer messages to deal with difficult situations in life (Pernicano, 2014). Moreover, children listening to stories, using metaphors and creating characters offer benefits as it allows communication of children with the social world on multiple levels (Gil, 2014). Child therapists use Milton Erickson's work of using story in therapies, with a belief that children can link the stories and/or characters with their own dispositions, prior experiences and can express their understanding and meaning of their own lives through stories (Carlson, 2001). In addition, learning through narratives can bring in the aspect of play and independence by creating, telling and writing stories (Hakkarainen et al., 2013; Hakkarainen, 2004). Therefore, using stories to teach science can provide an enquiry based platform for teachers to fulfil children's curious questions on 'how science relates to me and why developing scientific enquiry is important to people like me and to the surrounding community?', in other words, providing a reasonable context and meaning of science as an important element of the world they live in (Monhardt and Monhardt, 2006).

In addition, the usefulness of stories in science has been seen by many science educators. For example, Milne (1998) who classified four types of stories that can be helpful in science learning, which are: (i) heroic (scientists contributed to the development of science) (ii) discovery (scientific knowledge being gained accidently in history) (iii) declarative (scientific processes/concepts can be observed in nature by anyone) and (iv) politically correct stories (contribution of science to society). Allchin et al. (2014), adapting Clough's (2006) used the word cases representing stories and highlights the benefits of using decontextualized and contextualized scenarios, revealed merits and demerits of the three main modes which are: (i) contemporary cases, (ii) student based investigations and (iii) historical cases. They believe that these three approaches complement each other and should be used accumulatively to accommodate each other's demerits as it can then offer a full exposure to the world view.

Allchin (2014) and Tao (2003) from their studies reported that science stories, as narratives, helped the children to develop adequate understanding and positive views of science. The example given is of true stories, such as the stories of penicillin and small pox, newton's law of gravitation and the cure of the stomach ulcer. These true stories are definitely important however there needs to be some additional support from fiction based children stories to enhance understanding of the world, as it interests most of the children at an early years and primary stages. For example Monhardt and

Monhardt (2006) mentioned the usefulness of setting a scene for the learning of science process skills through picture books. Likewise, Piggott (2014) mentioned that fiction based stories helped project ideas into the future and aid discussions about the future direction of science and technology. In addition, Vrasidas et al. (2015) in the context of EU project “Science Fiction in Education” (Sci-Fi-Ed) and Hewlett (2016) suggest that reading science fiction stories makes children link scientific concepts with their own daily life experiences and in turn children can relate the characters of the story with their own understanding of the world.

In addition, in Salehjee (2017), I designed and implemented stories in science classrooms for 11-13 year old pupils. The stories used were linked to the science taught topics with an intention to develop scientific enquiry linking to historical and contemporary societal issues. For example learning topics on rusting, pollution and habitat behind particular scenes from a 1939 musical fantasy film adapted from L. Frank Baum's 900 Children’s book – The Wizard Oz. Moreover, topics on radiation and societal dilemma were taught through Z for Zachariah - science fiction film adapted from Robert C. O'Brien’s novel. Topics on brain and emotional changes experienced by a teenage girl were taught through the story of ‘Inside out’ – a Walt Disney’s animated drama film written by psychologists Pete Docter and Ronnie del Carmen. In addition, ‘Superman’ short episodes were incorporated in the enquiry based lessons to learn various laws of physics which superman makes use of to save the people, community and world. The results revealed a very positive impact on students learning of scientific concepts, scientific enquiry skills and linking everyday world with science (Salehjee, 2017).

Driving these benefits down into early childhood education entails a possibility that learning science through stories can help very young children to learn science by linking it with the physical world, people and community. I envisage three example stories below, suitable to the age group 4 – 8, linking to the statutory and/or un-statutory English curriculum. Before revealing the stories and associated activities, it is important to note that these stories and linked activities are not absolute examples, instead, a few ways of using stories for guidance. In designing similar plans teachers should wear their ‘thinking science’ hats on along with keeping teaching and learning context in mind.

The scientific enquiry based activities presented below, are divided into three stages (beginning, middle and end) and under each stages five EBL phases (Figure) are incorporated.

Example 1: Curious George's Low High Score

This example links to the material science topic on ‘different materials and their properties’ and also relating to the aspect of problem solving, scientific enquiry steps are as follows:

The beginning stage

(i) starting with ‘orientation’ phase involving telling and/or watching an episode, where Curious George is playing with a golf ball

(ii) at the ‘conceptualisation’ phase the teacher can ask students to predict the drop height and bounce height of a golf ball. In some cases the teacher can give a sentence and options to choose the correct answer such as: ‘higher the drop height ___________ (higher or lower or the same) is the bounce height’

The middle stage

(iii) after predicting, students can ‘investigate’ the relationship between ball drop and initial bounce. Children can devise appropriate equipment to measure and to record the results in teams with teacher’s guidance

(iv) then, after conducting the experiment students would be guided to ‘conclude’ their results in relation to the hypothesis made at the conceptualisation stage

During the middle stage, phases (ii) and (iii) will be repeated with a ping-pong ball, a rubber ball and with a tennis ball.

The end stage

(v) allow children to 'discuss' the accumulated inferences in an evaluative manner and to 'communicate' their findings as 'problem solvers' by giving (pictorial, oral and/or written) advice to Curious George on the nature of bounce and material used that can help him in playing table tennis, golf and tennis. In doing that most children will be able to do this through drawing or making annotations and some will also be able to write a few advisory sentences.

Some children with teachers scaffolding, might be able to 'extend' this enquiry based approach further to multiple levels. For example –all the balls are round/spherical so they bounce, however, the tennis ball is made of rubber and plastic which when it hits the ground comes back to its original shape (more elastic) and will bounce more as compared to the ping-pong ball which is made from film reel strips and moth ball materials.

In addition to the above example, various other instances from Curious George episodes can be used in the classrooms such as: the above instance can be linked to the physical sciences of force, speed and elasticity. Moreover, 'Feeling Antsy/Maple Monkey Madness' where George spots an army of ants walking in trails linking to biological science and 'Bee is for Bear' episode on honey making and stickiness (viscosity) of honey can be linked to the biological as well as material science part of the curriculum.

Example 2: The Choco River ride

This example links to the physical science topic on 'floating and sinking' and material science topics on 'solids and liquids'. Scientific enquiry steps are as follows:

The beginning stage

(i) starting with 'orientation' phase, portraying the scene from the Charlie and the Chocolate factory where Mr Wonka invite his guests for a ride on the Choco River and the aspect of reluctance shown by the guest

(ii) at the 'conceptualisation' phase teachers can ask children to predict/ indicate materials in the classroom which they think can sink or float on the Choco River and/or on the water

The middle stage

(iii) after predicting, students can 'investigate' the relationship among objects floating/sinking in 20 cm^3 of chocolate drink (acting as a choco-river). Children can choose some objects which they think can float or sink. For example pencil- wood, marshmallow, bronze- coin and solid chocolate bar. Further instructions will be provided to the children to devise appropriate tools to test fairly for example choosing the same size of the chosen objects, the same amount of chocolate drink, and the same shape of the container. Then record the results in teams with teacher's guidance

(iv) later, after conducting the experiment and recording the results children would need to 'conclude' their results in relation to the hypothesis generated at the conceptualisation phase

During the middle stage, steps (ii) and (iii) would be repeated with 20 cm^3 of water, 20 cm^3 of diluted chocolate drinks of varying strengths (like 5cm^3 of coco-powder and 15cm^3 of water, 10cm^3 of coco-powder and 10cm^3 of water and 15cm^3 of coco-powder and 5cm^3 of water). Moreover, making different concentrations of chocolate drinks will help the children to learn scientific skills of measurements and using appropriate measuring devices for example to measure coco-powder (solid) we use weighing scale where using calibrated measuring cylinders to measure volumes of water (liquid)

The end stage

(v) most children would be able to 'discuss' their findings by accumulating inferences in an evaluative manner that is how different volume of coco-powder and water can effect floating and sinking. Children can 'communicate' their findings by designing boats (annotated drawing and/or writing a short story) explaining the strength of the designed boat for Charlie and Oompa-Loompas's to move from one side of the factory to another through the Choco River

Some will be able to extend the above enquiry skills, for example by investigating further on why the shape of the ship should be streamlined, differences among small boats and large ships and how different it will be to float a boat on the river than on sea?

This enquiry based lesson using the story of Charlie and the chocolate factory can be used in teaching and learning science for other topics from biological, material and physical sciences as well. For example linking: 'states of matter' to lickable wallpaper, to ice cream that never melts, churned chocolate, choco-river; 'sound' to Wonka's musical nodes; 'pressure/ suction force' to Augustus Gloop and 'sense of taste' to Violet's three-course meal-flavoured ever-lasting chewing gum. Moreover, this story can also be linked to the aspect of trustworthiness, respect, good and bad aspects of the society.

Example 3: If I only had a brain/ heart

The below enquiry based lesson links to the biological science topics on 'living and non-living things' and 'ecosystems'. Scientific enquiry steps are as follows:

The beginning stage

(i) entails 'orientation' including the scenes 'if I only had a brain' by scarecrow and 'if I only had a heart' by tinman from Wizard of Oz

(ii) at the 'conceptualisation' phase, teachers could ask children to predict and classify the characters in the Wizard of Oz into living and non-living things. Characters like good witch, bad witch, munchkins, Toto, Dorothy, tin man, scarecrow, lion, flying monkey, Wizard of Oz and apple tree

The middle stage

(iii) after predicting, ask children to 'investigate' possible explanation why some are living and non-living?. For example why tin man without a heart is non-living (or not) and an apple tree without a heart is living (or not). Allow students to design a new character in teams, with a missing organ or tissue (like eyes, ears) or design a half human and half machine child who can help Dorothy to return back to Aunt Em

(iv) then, 'conclude' results by accumulating explanations and predicting what makes something living and others non-living in relation to humans, animals and plant organs, tissues and cells

In the middle stage (ii) and (iii) can be repeated by taking students to an outdoor visit to a local park. And asking children to: find similar patterns, classify and infer further as for how the living and non-living things from Emmerdale city differs from the living and non-living things at the park.

The end stage

(v) children can ‘discuss’ the accumulated results in an evaluative manner and can ‘communicate’ their findings by producing an oral or written short poetry on the above designed character starting with ‘if I only had …..’

Some children will be able to extend the above enquiry. By asking and investigating as why and how all living things are dependent on each other? What are the aspects of feeding relationships among living things and why nature entail a recycling process?

This story and associated scientific enquiry can be used in teaching and learning science for other topics, such as designing a costume for tin-man and scarecrow to protect them from rusting or fire linking to the ‘properties of materials’ and indicating the effect on rain while scarecrow was on fire or the effect of snow on tinman linking to the topic of ‘seasonal changes’. This story can also be linked to the aspect of friendship, determination, varying perceptions and interpretations of good and bad aspects of the community.

Summary

There are several points to make in this summary. First, every child has a curious and enquiry based nature, like Aslan, Sarah and Milly, but not all the children will become scientists. Therefore, our main concern should be to further scaffold children’s curious, imaginative and enquiry based nature towards (i) the appreciation of science in day-day activities and (ii) dealing with problems and issues through the lens of science. This paper, offer ways to practionners and teachers in scaffolding scientific knowledge and skills by using stories as a platform to implement EBL approaches with a belief that these on-going and hierarchical approaches of teaching and learning science will result in making a strong foundation in producing scientifically literate citizens for future.

Second, there is a need to incorporate depth and importance of EBL in the curriculum to accommodate scientific enquiry skills. ‘Understanding the world’ and ‘working scientifically’ themes in the curriculum related to scientific enquiry processes but the explanations used in the curriculum are unclear and limited. There are some attempts made in the curriculum to specify these ideas through examples but this does not give enough support to the early years and primary teachers to embed science within day-to-day teaching and learning practices. This paper attempted to practically demonstrate the embedding of EBL cycle for teachers to use it as a tool in planning lessons and activities. Moreover, ‘understanding the world’ and ‘working scientifically’ strands should be considered as an integral part of the entire curriculum. As the holistic curriculum is viewed to interconnect all the areas of learning and development – this is what Goswami and Bryant (2007) term multi-sensory approaches. Therefore, a suggestion here is to, use EBL cycle with an intention to not only teach science but also to integrate scientific language, mathematical skills and social issues within lesson plans.

Third, various attempts are made to help teachers in incorporating science teaching in early years and in primary education, for example Sure Start and Creative Star limited programmes. However, still teachers lack confidence in science subject knowledge which is acting as a barrier to teaching science. At this point, the recommendation for the practionners and teachers is to ‘redevelop’ their childlike scientific curiosity and incorporate multi-sensory approaches to avoid producing ‘unthinkable’ science teaching and learning processes. Therefore, this paper attempted the use of well-known children’s stories as examples in planning lessons while wearing scientific thinking hats. Whether fiction or non-fiction stories, it is important to utilise this approach as it entails an open platform for children in making meaning of science, practicing scientific enquiry processes, gathering information based on social, moral, cultural issues addressed in the stories, proposing ways to solve the mysteries and eventually appreciate the embeddedness of science in their lives.

This paper presents a framework mainly linking to England's curriculum, however, the benefits of incorporating science through stories is globally appreciated. As mentioned above, these stories and scientific enquiry based activities are not absolute, a few examples, to guide early year and primary teachers to ingrain scientific enquiry skills and knowledge to a higher level and establishing the true essence of understanding the world aspects of teaching and learning in classrooms.

References

Allchin, D., Andersen, H. M., & Nielsen, K. (2014). Complementary approaches to teaching nature of science: integrating student inquiry, historical cases, and contemporary cases in classroom practice. *Science Education*, 98(3), 461-486.

Allchin, D. (2012). Teaching the nature of science through scientific error. *Science Education*, 96, 904–926.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B. & Wong, B. (2014). *ASPIRES. Young people's science and career aspirations, age 10 –14*. London: Kings College.

Ault, C. R., & Dodick, J. (2010). Tracking the Footprints Puzzle: The problematic persistence of science-as-process in teaching the nature and culture of science. *Science Education*, 94(6), 1092-1122.

Australian Academy of Science (2013) *Science by doing: Engaging students with science. Enquiry based learning*. [Online]. [Accessed 08/01/207]. Available from: https://www.sciencebydoing.edu.au/portal/teacher/teacher-guide.html#footerMenu

Beauchamp G. (2016) Understanding the world. In Palaiologou, I. (Ed.). (2016). *The Early Years Foundation Stage: Theory and Practice*. Sage, pp. 423-438.

Blake, E. and Howitt, C. (2015) Developing pedagogical practices for science teaching and learning with 3 and 4-year-old children. In Campbell, C., Jobling, W., & Howitt, C. (Eds.). *Science in early childhood*. Cambridge University Press. Pp 101 -111.

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins and effectiveness*. Colorado Springs, Co: BSCS, 5, 88-98.

Campbell, C., Jobling, W., and Howitt, C. (Eds.). (2015). *Science in early childhood*. Cambridge University Press.

Cambell, C. and Chealuck (2015) Approaches to enhance science learning In Campbell, C., Jobling, W., & Howitt, C. (Eds.). *Science in early childhood*. Cambridge University Press: pages 67-84

Carlson, T. D., & Erickson, M. J. (2001). Honoring and privileging personal experience and knowledge: Ideas for a narrative therapy approach to the training and supervision of new therapists. *Contemporary Family Therapy*, *23*(2), 199-220.

Charlesworth, R. (2015). *Math and science for young children*. Cengage Learning.

Chin, C. C., Yang, W. C., & Tuan, H. L. (2016). Argumentation in a socioscientific context and its influence on fundamental and derived science literacies. *International Journal of Science and Mathematics Education*, *14*(4), 603-617.

Clough, M. P. (2006). Learners' responses to the demands of conceptual change: Considerations for effective nature of science instruction. *Science & Education*, 15(5), 463-494.

Coll, S. D., and Treagust, D. (2018). BLENDED LEARNING ENVIRONMENT: AN APPROACH TO ENHANCE STUDENTS'S LEARNING EXPERIENCES OUTSIDE SCHOOL (LEOS). *MIER Journal of Educational Studies, Trends and Practices*, 7(2).

Craft, A. (2002). Creativity and early years education: A life wide foundation. Bloomsbury Publishing.

Cremin, T., Glauert, E., Craft, A., Compton, A., & Stylianidou, F. (2015). Creative Little Scientists: exploring pedagogical synergies between inquiry-based and creative approaches in Early Years science. *Education* 3-13, 43(4), 404-419.

D'Arcangelo, M. (2000). The Scientist in the Crib: A Conversation with Andrew Meltzoff. *Educational Leadership*, 58(3), 8-13.

Daniel, G. R. (2016). Parents' experiences of teacher outreach in the early years of schooling. *Asia Pacific Journal of Education*, 36(4), 559-569.

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, 37(6), 582 – 601.

Department for Education (2017) *Statutory framework for the early years foundation stage. Setting the standards for learning, development and care for children from birth to five* https://www.foundationyears.org.uk/files/2017/03/EYFS_STATUTORY_FRAMEWORK_2017.pdf

Department for Education (2014) '*Children' educational and developmental outcomes at age 16', Effective Pre-school, Primary and Secondary Education (EPPSE 3-16) Project*. www.gov.uk/government/publications/influences-on-children-development -at-age-16.

Department for Education (2015) *Statutory guidance: National curriculum in England: science programmes of study*.

https://www.gov.uk/government/publications/national-curriculum-in-england-science-programmes-of-study/national-curriculum-in-england-science-programmes-of-study

Department for Education (2013) *Schools and Colleges Curriculum and qualifications*. Available

at https://www.gov.uk/schools-colleges/curriculum-qualifications

Department for Education (2012) *Statutory Framework for the Early Years Foundation Stage. Setting the standards for learning, development and care for children from birth to five.*

https://www.foundationyears.org.uk/files/2014/05/eyfs_statutory_framework_march_2012.pdf

Devi, A., Fleer, M., & Li, L. (2018). 'We set up a small world': preschool teachers' involvement in children's imaginative play. *International Journal of Early Years Education*, 1-17.

DeWitt, J., Osborne, J., Archer, L., Dillon, J., Willis, B., & Wong, B. (2013). Young children's aspirations in science: The unequivocal, the uncertain and the unthinkable. *International Journal of Science Education*, 35, 1037–1063.

Dockett, S. & Fleer, M. (2002). *Play and pedagogy in early childhood: Bending the rules*, Melbourne: Thomson.

Egan, K., Cant, A.I. and Judson, G. eds. (2013). *Wonder-full education: The centrality of wonder in teaching and learning across the curriculum*. New York and London: Routledge.

Egan, K. (2010). Learning in depth: *A simple innovation that can transform schooling*. Chicago: University of Chicago Press.

Egan, K. and Madej, K.R.Y.S.T.I.N.A. (2009). Learning in depth: Students as experts. *Education Canada*, 49(2), pp.18-23.

European Commission (2007) *European Commission Science education now: A renewed pedagogy for the future of Europe.* [Online]. [Accessed 09/01/2016]. Available from: http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf

Gallagher, A., Finlayson, O., & McCloughlin, T. (2012*). Cognitive acceleration in infant classes: testing scientific thinking skills. Proceedings of the primary science symposiun: science live for teachers*. Dublin, RDS/CASTeL. pp30-34.

Gentner, D., & Colhoun, J. (2008). Analogical processes in human thinking and learning. In B. Glatzeder, V. Goel, & A. Muller (Eds.), *Towards a theory of thinking* (pp. 35–48). Berlin, Germany: Springer.

Gil, E. (2014). The creative use of metaphor in play and art therapy with attachment problems. *Creative arts and play therapy for attachment problems*, 159-177.

Glauert, E., & Manches, A. (2013). *Creative little scientists: Enabling creativity through science and mathematics in preschool and first years of primary education*. D2. 2. Conceptual framework.

Goswami, U., & Bryant, P. (2007). *Children's cognitive development and learning*. Available at:

https://www.cne.psychol.cam.ac.uk/pdfs/publication-pdfs/Primary_Review_2-1a_report_CogDevLearn_Goswami-Bryant_2007.pdf [Accessed 17/05/2018]

Grosemans, I., Boon, A., Verclairen, C., Dochy, F., & Kyndt, E. (2015). Informal learning of primary school teachers: Considering the role of teaching experience and school culture. *Teaching and Teacher Education*, 47, 151-161.

Hakkarainen, P., Brėdikytė, M., Jakkula, K., & Munter, H. (2013). Adult play guidance and children's play development in a narrative play-world. *European Early Childhood Education Research Journal*, *21*(2), 213-225.

Hakkarainen, P. (2004). Narrative learning in the fifth dimension. *Outlines. Critical Practice Studies*, *6*(1), 5-20.

Haraway, D. J. (2013). *Primate visions: Gender, race, and nature in the world of modern science*. Routledge.

Harlen, W. (2017). *The teaching of science in primary schools*. David Fulton Publishers.

Harlen, W., & Holroyd, C. (1997). Primary teachers' understanding of concepts of science: Impact on confidence and teaching. *International journal of science education*, 19(1), 93-105.

Haury, D. L. (2002). *Fundamental Skills in Science: Observation. Columbus, OH: Clearinghouse for Science Mathematics and Environmental Education*. ERIC Document Reproduction Service No. ED478714).

Hepworth, M. and Walton, G. (2009) *Teaching Information Literacy for Enquiry-Based Learning*. Oxford, Cambridge, New Delhi: Chandos Publishing.

Hewlett, C. (2016). *Why use Fiction?. In Teaching Science in the Primary Classroom.* [Online] [Accessed 23/12/2016]. Available from:https://books.google.co.uk/books?hl=en&lr=&id=3T1DCgAAQBAJ&oi=fnd&pg=PT135&dq=science+fiction+ofsted&ots=r5xYO-HVGJ&sig=IRulqL-54TGrW7TKkPk_kzNUSG0#v=onepage&q&f=false

Holbrook, J., & Rannikmae, M. (2007). The nature of science education for enhancing scientific literacy. *International Journal of Science Education*, 29(11), 1347-1362.

Howe, N., Della Porta, S., Recchia, H., Funamoto, A., & Ross, H. (2015). "This Bird Can't Do It 'Cause this Bird Doesn't Swim in Water": Sibling Teaching During Naturalistic Home Observations in Early Childhood. *Journal of Cognition and Development*, 16(2), 314-332.

Hutchings, W. (2007). *Enquiry-Based Learning: Definitions and Rationale. Manchester: Centre for Excellence in Enquiry-Based Learning*.

Jensen, J. L., Kummer, T. A., & Godoy, P. D. D. M. (2015). Improvements from a flipped classroom may simply be the fruits of active learning. *CBE-Life Sciences Education*, 14(1), ar5.

Justice, W. Warry, C.L. Cuneo, S. Inglis, S. Miller, J. Rice (2002). *A grammar for enquiry: Linking goals and methods in a collaboratively taught social sciences enquiry course*. The Alan Blizzard Award Paper: The Award Winning Papers.

Kambouri, M. (2016). Investigating early years teachers' understanding and response to children's preconceptions. *European Early Childhood Education Research Journal*, 24(6), 907-927.

Kuhlthau, C.C., Maniotes, L.K. and Caspari, A.K. (2015). *Guided Enquiry: Learning in the 21st Century: Learning in the 21st Century*. 2nd Ed. USA: ABC-CLIO.

Kuhn, D., Black, J., Keselman, A., & Kaplan, D. (2000). The development of cognitive skills to support inquiry learning. *Cognition and Instruction*, 18(4), 495-523.

Lederman, N. G., Lederman, J. S., & Antink, A. (2013). Nature of science and scientific inquiry as contexts for the learning of science and achievement of scientific literacy. *International Journal of Education in Mathematics, Science and Technology*, 1(3).

Lee, H., Yoo, J., Choi, K., Kim, S. W., Krajcik, J., Herman, B. C., & Zeidler, D. L. (2013). Socioscientific issues as a vehicle for promoting character and values for global citizens. *International Journal of Science Education*, *35*(12), 2079-2113.

Lourenço, O. M. (2016). Developmental stages, Piagetian stages in particular: A critical review. *New Ideas in Psychology*, 40, 123-137.

Lloyd, E., Edmonds, C., Downs, C., Crutchley, R., & Paffard, F. (2017). Talking everyday science to very young children: a study involving parents and practitioners within an early childhood centre. *Early Child Development and Care*, *187*(2), 244-260.

McCormack, L., Finlayson, O. E., & McCloughlin, T. J. (2014). The CASE programme implemented across the primary and secondary school transition in Ireland. *International Journal of Science Education*, *36*(17), 2892-2917.

Milne, C. (1998). Philosophically correct science stories? Examining the implications of heroic science stories for school science. *Journal of Research in Science Teaching*, 35(2), 175-187.

Minner, D.D., Levy, A.J. and Century, J. (2010). Enquiry-based science instruction—what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of research in science teaching*. 47(4), pp.474-496.

Monhardt, L., & Monhardt, R. (2006). Creating a context for the learning of science process skills through picture books. *Early Childhood Education Journal*, *34*(1), 67-71.

Murphy, C. and Beggs, J. (2005). Coteaching as an approach to enhance science learning and teaching in primary schools. *Counterpoints*. 294, pp.207-231.

Nespor, J. (1998). The meanings of research: Kids as subjects and kids as inquirers. *Qualitative Inquiry*, 4(3), 369-388.

The Office for Standards in Education, Children's Services and Skills *(*Ofsted) (2017) *Bold beginnings: The Reception curriculum in a sample of good and outstanding primary schools*. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/663560/28933_Ofsted_-_Early_Years_Curriculum_Report_-_Accessible.pdf [Accessed 13/04/2018]

Ofsted (2013) *Going in the right direction?* [Online]. [Accessed 10/10/14]. [Available from:https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/413171/Going_in_the_right_direction.pdf

Ofsted (2013) *Subsidary Guidance: Supporting the Inspection of Maintained Schools and Academies*. Reference no. 110166. London: Ofsted.

OECD (2012) *PISA 2012 assessment and analytical framework: Mathematics, reading, science, problem solving and financial literacy*. Paris: OECD Publishing.

OECD. (2009). PISA 2009 assessment framework. Paris: Author. Retrieved March 14, 2014, from http://www.oecd.org/pisa/pisaproducts/44455820.pdf.

Osborne, J. (2014). Teaching scientific practices: Meeting the challenge of change. *Journal of Science Teacher Education*. 25(2), pp.177-196.

Peacock, G., Sharp, J., Johnsey, R., Wright, D., & Sewell, K. (2017). *Primary science: knowledge and understanding. Learning Matters*.

Pedaste, M., Mäeots, M., Siiman, L.A., De Jong, T., Van Riesen, S.A., Kamp, E.T., Manoli, C.C., Zacharia, Z.C. and Tsourlidaki, E. (2015). Phases of enquiry-based learning: Definitions and the enquiry cycle. *Educational research review*. 14, pp.47-61.

Piggott, A. (2014). In Your View: What Is a Good Science Teacher?. *Education in Science*.257, pp.14-15.

Rogers, V. (2012). Early Years: Where Does Science Fit In?. *Primary Science*, 123, 28-30.

Salehjee, S., & Watts, M. (2018). Models of scientific identity. In, S. Pabst (ed.) *Science and Technology Education: Perspectives, Opportunities and Challenges*. Hauppauge, New York, NOVA Science Publishers.

Salehjee, S. Q. (2017). *Making scientists: developing a model of science identity* (Doctoral dissertation, Brunel University London).

Savery (2015) Overview of Problem based learning: definitions and distinctions. In Ertmer, P.A., 2015. *Essential Readings in Problem-based Learning. Purdue*: Purdue University Press.

Sharp, J., Peacock, G., Johnsey, R., Simon, S., Smith, R., Cross, A., & Harris, D. (2017). *Primary science: teaching theory and practice*. Learning Matters.

Tao, P. K. (2003). Eliciting and developing junior secondary children' understanding of the nature of science through a peer collaboration instruction in science stories. *International Journal of Science Education*, 25(2), 147-171.

Trumbull, D. J., Scarano, G., & Bonney, R. (2006). Relations among two teachers' practices and beliefs, conceptualizations of the nature of science, and their implementation of student independent inquiry projects. *International Journal of science education*, 28(14), 1717-1750.

van Aalderen-Smeets, S. I., Walma van der Molen, J. H., van Hest, E. G. C., & Poortman, C. (2017). Primary teachers conducting inquiry projects: effects on attitudes towards teaching science and conducting inquiry. *International journal of science education*, 39(2), 238-256.

Van Aalderen-Smeets, S. I., Walma van der Molen, J. H., & Asma, L. J. F. (2012). Primary teachers' attitudes toward science: A new theoretical framework. Science Education, 96, 158–182.

Vrasidas, C., Avraamidou, L., Theodoridou, K., Themistokleous, S., & Panaou, P. (2015). Science Fiction in Education: case studies from classroom implementations. *Educational Media International*, 52(3), 201-215.

Waters-Adams, S. (2006). The relationship between understanding of the nature of science and practice: The influence of teachers' beliefs about education, teaching and learning. *International Journal of Science Education*, 28(8), 919-944.

Zeidler, D. L., Walker, K. A., Ackett, W. A., & Simmons, M. L. (2002). Tangled up in views: Beliefs in the nature of science and responses to socio-scientific dilemmas. *Science Education*, 86(3), 343–367.