Module 12: Reflection and reasoning

Aims of the module:

- Increase awareness of the role of reflection and consideration of alternative ideas in supporting children's understanding of scientific ideas and procedures and development of creativity
- Introduce participants to different forms of questioning at appropriate points to encourage children's reflection and explanation
- Share strategies for facilitating exchange of ideas within groups and across the class.

Links to the Content Design Principles and Outcomes

3. Teacher education should advance teachers' understandings about the nature of science and how scientists work, confronting stereotypical images of science and scientists.

3.2 Teachers should be able to recognize young children's capabilities to engage with processes associated with the evaluation as well as generation of ideas in science and mathematics, since these processes are also important for the development of learner creativity

3.3 Teachers should be able to use foster the processes of imagination, reflection and consideration of alternative ideas in supporting children's understanding of scientific ideas and procedures and development of creativity.

11. Teacher education should enable teachers to use questioning effectively and encourage children's questions in order to foster creativity and inquiry

11.1 Teacher should be able to use different forms of questioning at appropriate points to scaffold creative learning outcomes in science and mathematics, and in particular to encourage children's reflections and explanations, foster their independence and extend their inquiry.

15. Teacher education should promote teachers' use of group work to support children's inquiry processes and creative learning.

15.6 Teachers should be able to use effective strategies for sharing ideas and discussions from different groups.

Rationale for the module

Why is reflection and reasoning important in science learning?

As noted in the Conceptual Framework adopted by the CEYS Project (Creative, Little Scientists, 2012), perspectives on science education highlight the importance of reflection and reasoning in science learning, emphasising the importance of metacognitive processes, reflective awareness and deliberate control of cognitive activities, which may still be developing in young children but which are incorporated into early years practice, science learning and inquiry-based approaches to science education.

Before they begin more formal learning in school children accumulate a wealth of experiences in informal contexts. These experiences foster children's motivation to understand their world. From as young as two or three, children are able to make causal inferences about information they gain from the environment, demonstrating abilities to reason and reach conclusions, although not necessarily verbally (Gopnik, Sobel, Schulz, and

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Glymour, 2001). An important priority in the early years of education is to build on and extend children's emerging skills and understandings.

Inquiry based approaches to science education seek to help children make use of their experiences, from home, school and in the wider world, as 'data' with which to generate and evaluate different ideas. They aim to support children in reflecting on this data and using reasoning to try to develop scientific theories. This is similar to the generation and evaluation of ideas in creativity. However, Metz (2004) found that children need help and encouragement to do this because they tend to just think about their evidence in terms of their existing theories. According to Goswami and Bryant (2007) young children are capable of this 'explanation-based' or causal learning but scientific reasoning tends to require dealing with multiple causal variables and this takes longer to develop. Nevertheless, there is research evidence that shows children can reason scientifically, test a hypothesis and recognise conclusive tests (Duschl, et al., 2007; Eshach and Fried, 2005).

The teacher can scaffold this development by providing opportunities for sharing, testing and evaluating ideas. It is important to create a supportive climate that encourages questioning, attempts at explanation, debate and reflection. The teacher has a key role in modeling these processes and attitudes such as curiosity, being open to new ideas and critical reflection. Wellman and Lagattuta (2004) recommend that getting children to explain their reasoning and that evaluating and commenting on each other's explanations is important in developing reasoning. Whether the reasoning is expressed through dialogue, in writing, through a diagram, by drawing, in a video or through drama, the key aspect is helping the children to think about how they think.

There is evidence of the considerable benefits of collaborative work in groups and class discussion in fostering children's reflection and reasoning (Wood and O'Malley, 1996). Talking aloud gives children's opportunities to think aloud Indeed, the very process of explaining thinking verbally can help consolidate ideas (Chi, De Leeuw, Chiu, and Lavancher, 1994) and create opportunities for developing children's exploratory talk with others (Mercer, Wegerif, and Dawes, 1999). The communication of ideas and ways of thinking allows children to listen to alternative ideas and contrast their own way of thinking. Through collaborative activities, children gain access to a wider range of problem-solving strategies (Mercer and Littleton, 2007). This gaining of awareness promotes, in some, the need to restructure their ideas, in face of other more plausible and consensual ones that appear in the social context of the class (Varela, 2010)

The collaborative nature of learning also has the potential to make children more attentive to their own thoughts and those of others. It can stimulate the need to clarify or modify thoughts, based on peers' comments and reactions. Children also learn, by the action of others, to monitor and auto-regulate their own thoughts. Group work may therefore benefit processes such as children's metacognition (Littleton, et al., 2005).

As the commentary above suggests, teacher questioning and the management of group work play key roles in fostering reflection and reasoning. These aspects of the role of the teacher are explored in more detail in Module 1 Using questions of teachers and children and Module 6 Collaboration and group work. There are also particular challenges in holding class discussions. The background resources produced by the Fibonnaci project (Fibonacci project 2012 p10) offer a range of practical suggestions for fostering productive exchange of ideas including:

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- Making sure all children can see each other - seating for example in a circle or turning round to face each other
- Slowing down discussion to help children join in – for example asking children to wait for a few seconds, waiting for 5-10 seconds when there is silence can deepen a discussion or release new ideas.
- Explicit encouragement to children to talk to one another (rather than the teacher) – such as "Talk back to Louis, not to me", "Amahl had a question for you", "Marie, what did you think about what Sam said?", "Allen, do you have anything to add to what Jeanne said?"
- Handling naïve conceptions when they are shared – early on you may accept a naïve idea while at the same time highlighting results that raise questions about it, later on you may guide the class to a more accurate conception based on evidence and reasoning.
- How to handle questions that cannot be answered by investigation or which the teacher may not be able to answer – one possible approach they recommend is to write them on the board, leaving none out, then sorting them into categories for example - questions that might be investigated successfully through direct experience, questions that can be adapted for investigation, and questions that cannot be answered though first hand investigation (will need research from second hand sources. They also suggest that saying "I don't know, but we can find out" models good (scientific) behaviour.

Finally opportunities for participation in scientific inquiry and debate in the classroom community play an important role in developing children's understandings of the nature of science. In particular the processes of sharing, testing and evaluating ideas can foster an appreciation of scientific argumentation and explanation. This is explored further in Module 3 Focus on the nature of science.

What are the challenges for teachers?
Key issues in fostering reflection and reasoning in science include:

- How to stimulate and gain access young children's ideas and thinking
- Strategies for supporting children's reasoning
- Ways to generate a supportive climate in which children feel confident to share ideas and make mistakes.

Overview of the module

The module consists of the following activities:

1. **Introduction: aims and rationale for the module**: introduction to the central role of reflection and reasoning in creative, inquiry based approaches to science learning.
2. **Participants' experiences in science education: opportunities for reflection and reasoning.** Participants are encouraged to share their own memories of science in their own schooling – Were there opportunities for reflection? What stimulated, supported or hindered reflection? What was the potential for creativity? What was the impact on learning?
3. **Discussion activities - potential for stimulating reflection and reasoning**: Participants explore the potential of a range of activities designed to stimulate reasoning and discussion of alternative ideas. They consider questions the teacher might ask to foster discussion, issues the activities might raise and possible follow up activities.

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4. **Practical activities - fostering reflection based on evidence**: Participants engage in practical activities. They reflect on evidence, discuss alternative explanations and strategies.
5. **Examples from practice: opportunities for reflection within everyday classroom activities:** Participants review Curriculum Materials from the CEYS project. What evidence can you see of children's reflection and reasoning? How does this change over time? What aspects of the classroom environment prompt reflection?
   Can you identify connections to creative dispositions ? How could opportunities for reflection and reasoning be extended? How might you make links with the nature of science?
6. **Implications for planning:** Participants consider implications for their own classroom in relation to pedagogical model utilized by Siraj-Blatchford et al (2002) in their research into effective pedagogy in the early years.
7. **Reflections on what has been gained from the module.** Participants reflect what has been gained from the module – both process and content.

Module at a glance

Time	Task	Materials	Grouping
00.00	1**. Introduction: aims and rationale for the module.**	Powerpoint presentation • Aims • Links to Content Design Principles and Outcomes • Module outline Handouts of CEYS definitions of creativity, features of inquiry and creative dispositions for use during the session	Whole group
00.10	2**. Participants' experiences in science education: opportunities for reflection and reasoning** *In pairs* • Share your experiences of science learning in school. Can you identify opportunities provided for reflection and reasoning? • What did you focus on – science ideas, inquiry processes, attitudes, other? • In what ways (if any) did this support your learning? • What stimulated you to reflect? • What hindered reflection? *On your table* • Share and record your ideas on the sheet provided – annotate to identify similarities and differences in your experiences *Whole group* Share factors that stimulated/hindered reflection. What are the implications?	A3 recording proforma for groups to share and record. Pens, highlighters to draw out similarities and differences. Powerpoint slides of task A1 Flip chart to record summary of views Marker pens Blutak to display the chart for review at the end of the session. Powerpoint slides Reflection and reasoning in early years science Challenges Gaining access to ideas	*Pairs* *Group* discussion and recording Followed with feedback with whole group
00.30	**3. Discussion activities: potential for fostering reflection and reasoning** *Work in groups of 4 or 5* Set of activities for discussion on each table • What kinds of discussion might be prompted by these activities?	Powerpoint slide of activities and questions to consider. Activity sheets and resources for each activity. A3 recording sheet. Pens pencils to record responses	Groups 4 or 5 Followed by whole group

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	• How might you promote discussion of alternative science ideas and explanations? • Can you identify ways in which you might use or adapt these approaches in your setting? • What other approaches might you use? Whole group feedback on one or two issues raised by these activities	Flip chart Marker pens, Blutak Keep record of issues and applications for learning wall.	
1.15	Break		
1.30	**4. Practical activities – fostering reflection and reasoning** Divide into two large groups A and B Group A: Rolling Tubes Group B Colour Spinners Groups carry out the activities. Then reflect on their investigations. Make notes on: • What have you observed? • Have you noticed any patterns ? • How could you explain this? Are there any alternatives? • How have your ideas changed? Why? • How might your investigation be improved? • What further questions do you have? • In what ways were you acting like scientists? Discussion with the whole group: Comparing findings and approaches • What did you discuss? • What raised/prompted this discussion? • What evidence did you draw on? • How did you record your results? In what ways did this support your developing thinking? • What issues did the activities raise? • What questions could teachers ask to stimulate reasoning? • What were the opportunities for creativity?	Powerpoint slides of Activities Reflecting on evidence Implications for teaching Instructions and resources for the activities Flip chart and pens to share responses. .	Groups 4 Followed by whole group discussion.
2.00	**5. Opportunities for reflection within everyday classroom activities** *In 4s* review and analyse curriculum examples from the CEYS Project with a focus on the following: • What evidence can you see of children's reflection and reasoning? • How does this change over time? • What aspects of the classroom environment prompt reflection? • Can you identify connections to creative dispositions? Annotate record to highlight connections • How could opportunities for reflection and reasoning be extended? • How might you make links with the nature of science? Review one example in pairs and record findings. If time swap with the other pair who add to the recording sheet. *Whole group* summary:	*Materials* Each group of 4 has 2 copies of 3 or 4 different examples of Curriculum Materials to share plus an A3 sheet to record their analysis. Powerpoint slides of the task and showing key details from the examples selected to support whole group discussion. Handouts and Powerpoint slides of creative dispositions, CEYS definition of creativity and characteristics of the nature of science	*Groups of 4* divided into 2 pairs. Suggest new groups after break. Followed by *whole group* discussion.

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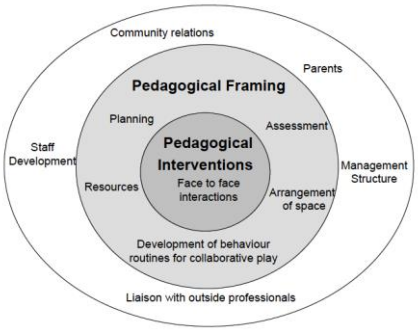
	• Sources of evidence of children's reflection and reasoning • Nature of change • Stimulus to reflection and reasoning • Creative dispositions		
2.30	**6. Implications for the teacher** Discuss implications for the teacher in relation to the pedagogical model (Siraj Blatchford et all 2002).  Annotate the diagram to show implications for the classroom environment – for both pedagogical interactions and pedagogical framing *Groups of 4 if time* *In whole group* – share suggestions Note any issues raised.	Powerpoint slide of pedagogical model *If time for group activity* A3 Recording sheet with pedagogical model at the centre. Annotate to indicate implications. Flip chart and pens A1 copy of pedagogical model	Whole group
2.45	**7.Reflections on what has been gained from the module** *In groups of 4* • Look back at your original chart of factors that help and hinder reflection and reasoning (from activity 2) • Is there anything you would add? • In what ways did the different activities during the module support your developing thinking? *As a whole group* share any ideas participants are ready to offer *Individually* – complete evaluation form. How far have the aims of the module been met?	Powerpoint slides of activity and aims Add to recording from activity 2 Pens Flip chart and marker to record key suggestions Evaluation forms	Groups of 4 to reflect on initial ideas and any further suggestions. Sharing with the whole group
3.00	End		

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Teacher education pedagogy

1. Introduction: aims and rationale: This module draws on the definition of creativity in early years science developed in the Creative Little Scientists project and key features of inquiry-based approaches to science education. You may find it useful to provide opportunities for participants to become familiar with these prior to the workshop. The final reports of the project provide a good starting point. Details are provided in the support materials below. Handouts of the CEYS definitions of creativity, features of inquiry and creative dispositions are included in module resources for use across the session.

2. **Participants' experiences in science education: opportunities for reflection and reasoning.** This activity is designed to draw on participants' own experiences to reflect on the kinds of approaches and experiences that stimulated reflection and reasoning but also to make connections back to teaching approaches that may have hindered sharing of ideas. This may also prompt memories about social and affective factors that were influential. Establishing a safe classroom environment is critical where children feel able to make tentative suggestions, make mistakes and change their ideas.

3. Stimulating reflection and reasoning: discussing alternative ideas.
This part of the session is designed to introduce a range of possible discussion activities to foster reflection and reasoning and debate about alternative ideas**.** The group is provided with a range of materials to share. The following examples are provided as starting points: Exploring materials, Odd one out, Positive minus interesting, Concept cartoons, Developing concept maps. You could also use examples of reflection and reasoning from the episodes of practice from the Creative Little Scientists project such as: *Sorting and classifying, Discussion of photographs of activities or children's recording*. You may include others appropriate to your audience and context. These are shared between group members.
Recording is designed to draw out the potential of each activity for the discussion of alternative scientific ideas and to consider the kinds of questions teachers can ask to foster reasoning and involve all the children. Participants are encouraged to reflect on adaptations and other possibilities for use in their settings.

4. Practical activities – reflection on evidence
Two practical activities are suggested – rolling tubes and coloured spinners. They have been chosen because both can be completed quite quickly with limited equipment and foster discussion of patterns and explanations based on observations but other local examples would be possible. Participants work in groups of 4 to carry out one of the activities. It is helpful if groups carry out different activities as they provide different types of opportunity for discussion.. In reviewing their activities, participants are asked to reflect on their inquiry processes and ways in which teachers can support reflection. Facilitators can model these processes in sharing findings and processes across the group (as several groups will have carried out the same activity). There are often opportunities to compare findings, discuss alternative ideas and strategies, drawing out links to the nature of science and the CEYS definitions of creativity

5. Opportunities for reflection within everyday classroom activities. As in all modules the classroom examples have considerable potential to foster interest and encourage debate. However participants may need support initially in engaging with the evidence shown in the episodes and templates. It is helpful if the module facilitators are familiar with the background to the classroom examples selected and provide a brief introduction to each one at the start of the activity.. The range of questions is designed to encourage participants to

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reflect on evidence of children's reflection and reasoning, ways in which it changes over time and the role of the teacher in stimulating and supporting reflection. Connections are made with two key themes discussed across all modules – opportunities for promoting creative dispositions and developing understanding of the nature of science. It is best for each pair to start by examining one example in detail recording their thoughts on the sheet provided. If there is time they could swap examples and recording sheets with the other pair in their group and *add* to their records rather than start a new record sheet (for reasons of time and attention).

6. Implications for the teacher. The pedagogical model employed by Siraj-Blatchford et al (2002) in their study of effective early years pedagogy provides a useful framework for considering ways in which both pedagogical interactions and pedagogical framing can support reflection and reasoning. This could either be carried out with participants working in small sub-groups or through brainstorm with the whole group depending on time. Some suggestions drawn from the Fibonacci Project (2012) are include in the powerpoint presentation for the module.

7.Reflections on what has been gained from the module. Recording from task 2 provides a useful starting point for participants to review their discussions and learning across the module and the implications for practice. It is often supportive to share ideas about classroom implications. It is helpful to encourage consideration of the processes as well as the content of learning to feed into module evaluations.

Background reading

Potential for inquiry and creativity in early years science

The executive summaries of the Final Reports of the Creative little Scientists project

- D6.5 Final Report on Creativity and Science and Mathematics Education for Young Children EXECUTIVE SUMMARY
- D6.6 Recommendations to Policy Makers and Stakeholders on Creativity and Early Years Science EXECUTIVE SUMMARY

provide an accessible introduction to the definitions of creativity and inquiry used during the session, with illustrations from the classroom. These documents can be found on the CLS website at http://www.creative-little-scientists.eu/content/deliverables. They also provide and overview of findings and recommendations from the project that informed the design of these teacher education modules.

Supporting reflection and reasoning

Reasoning and argumentation has received increased attention in recent years. Some examples of recent research and debate are provided below.

Akerson, V., Weiland, I., Pongsanon, K. & Nargund, V. (2011)
Evidence-based strategies for teaching Nature of Science to young children. *Journal of Kirsehir Education*, 11(4): 61-78.
Offers a framework for developing ideas about the nature of science with young children.

Chin, C. and Teou, L. (2009). Using concept cartoons in formative assessment: scaffolding students' argumentation. *International Journal of Science Education*, 31(10), 1307-1332.
The purpose of this study was to investigate how concept cartoons, together with other diagnostic and scaffolding tools, could be used in formative assessment, to stimulate children's talk and argumentation in small groups, as part of peer and self assessment.

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Fibonnaci Project (2012). *Inquiry in science education* available at http://fibonacci-project.eu
This provides a helpful overview of key aspects of teaching science through inquiry, reflecting current perspectives in the field. This includes practical suggestions for supporting reflection and reasoning.

Mant, J., Wilson, H. and Coates, D. (2007). The effect of increasing conceptual challenge in primary science lessons on pupils' achievement and engagement. *International Journal of Science Education,* 29(14), 1707-1719.
This paper reports on research into the effect on 11-year old pupils of introducing more cognitively challenging, practical and interactive lessons. Although this reports on work with older children some of the suggested approaches can be adapted for use with young children.

Mercer, N. et al (2004). Reasoning as a scientist: ways of helping children to use language to learn science. *British Educational Research Journal*, 30(3), 359-377.
Reports on findings from an experimental teaching programme designed to enable children in primary schools to talk and reason together and apply these skills in their study of science.

Siry, C. & Lang, D. (2010). Creating participatory discourse for teaching and research in early childhood science. *Journal of Science Teacher Education,* 21(2), pp149-160.
This study examined the possibilities for engaging children in critical discourse about their classroom science experiences.

Warwick, P. and Siraj-Blatchford, J. (2006). Using data comparison and interpretation to develop procedural understandings in the primary classroom: case study evidence from action research. *International Journal of Science Education*, 28(5), 443-467.
Case study evidence from a collaborative action research project that focused on the use of secondary data as a tool for stimulating engagement with procedural understanding among primary children.

Examples of professional publications that suggest strategies for supporting reflection and reasoning include are listed below. Some of the activities used in the session are drawn from these publications.

Earle, S. (2009). Using video to consider and evaluate evidence. *Primary Scien*ce 106, 18-20.
Shows how children can use video evidence of their investigations to develop higher order science skills.

Keogh, B. and Naylor, S. (1998). 'Teaching and learning in science using Concept Cartoons', *Primary Science Review*, 51, 14–16.
Ideas about how concept cartoons can be used to support science learning, building on children's ideas.

Maloney, J. (2005). What's the alternative? *Primary Science Review* 89, 14-16.
Describes how some children went about making decisions during science activities - how far they considered alternatives.

Naylor, S. and Keogh, B. (2010) (revised edition) *Concept Cartoons in Science Education*. Sandbach: Millgate House.
The books of concept cartoons published by Millgate House include many examples that can be used and adapted across the science curriculum.

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Primary Science Teaching Trust (PSTT) funds projects to develop professional development materials and resources to bring new ideas to the classroom. A wide range can be accessed on their website at https://pstt.org.uk

Bright ideas was a PSTT project designed to enhance children's thinking skills. The activities developed are illustrated and you can access suggestions for the activities Odd one Out. https://www.pstt-cpd.org.uk/ext/cpd/bright-ideas/acknowledgements.html

Tolson, S. (2011). Engaging critically with scientific evidence. *Primary Science*, 2011, 27-29. Examines ways to support children in working critically with evidence.

Suggested classroom examples for use during the module

The following Classroom materials act as useful starting points for discussion

For inclusion in Activity 3

From the *Creative Little Scientists* project at http://www.creative-little-scientists.eu/content/deliverables.

Selected Classroom Episodes: FR Magnet attraction or not, GE Building Blocks, PT Wolf, sheep, cabbage, RO Float and Sink, UKSC Forest School in D4.4 Appendix Selected Episodes of Practice

Classroom Templates: BE The Wind, UKEN Waterproof Materials in Addendum to D5.3.

For Activity 5

From the *Creativity in Early Years Science Project at* http://www.ceys-project.eu

Curriculum Materials

Title	Age group	Country
Crime Scene investigation	7-8	England
Electricity	4-5	England
Air resistance	5-6	England
An icy adventure	3-4	England
Castles and moats	4-5	England
Snails	3-4	England
Floating boats	5-6	Greece
The sounds around us	6-7	Greece

Module resources

The following documents are provided as separate files in the Module folder for adaptation and use as appropriate during the module:

- Powerpoint presentation
- Task 3 Discussion activities – see notes below slide 1 for resources
- Task 4 Practical activities with list of resources – Rolling Tubes and Colour Spinners – see notes below the slides for suggested resources
- Recording sheets for the different activities:
  - Task 2: Recording proforma for participants to record and reflect on their experiences of science learning in school
  - Task 3 recording sheet: Discussion activities: potential for fostering reflection and reasoning
  - Task 5 recording sheet: Opportunities for reflection within everyday classroom activities
  - Task 6 recording sheet Implications for the teacher. Recording sheet with pedagogical model (Siraj Blatchford et all 2002) at the centre to be copied as A3.

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- Handouts
  - Definitions of creativity in early years science, features of inquiry and creative dispositions
  - Characteristics of the nature of science

References

CREATIVE LITTLE SCIENTISTS (2012) *Conceptual Framework.* Deliverable D2.2. Available at: http://www.creative-little-scientists.eu/content/deliverables

Chi, M. T. H., De Leeuw, N., Chiu, M.-H. and Lavancher, C. (1994). Eliciting self-explanations improves understanding. Cognitive Science, 18(3), 439-477.

Duschl, R. A., Schweingruber, H. A., and Shouse, A. W. (2007). *Taking science to school: Learning and teaching science in grades K-8*: Washington, DC: National Academy Press

Eshach, H., And Fried, M. N. (2005). Should science be taught in early childhood? *Journal of Science Education and Technology, 14*(3), 315-336.

Gopnik, A., Sobel, D. M., Schulz, L. E., & Glymour, C. (2001). Causal learning mechanisms in very young children: Two-, three-, and four-year-olds infer causal relations from patterns of variation and covariation. *Developmental Psychology, 37*(5), 620-629.

Goswami, U., and Bryant, P. (2007). Children's cognitive development and learning. In R.Alexander (ed.), *The Cambridge primary review research surveys* 141-169. London: Routledge.

Littleton, K., Mercer, N., Dawes, L., Wegerif, R., Rowe, D. And Sams, C. (2005). Talking and thinking together at Key Stage 1. Early Years: An International Journal of Research and Development, 25(2), 167-182.

Metz, K. E. (2004). Children's understanding of scientific inquiry: Their conceptualization of uncertainty in investigations of their own design. *Cognition and Instruction, 22*(2), 219-290.

Mercer, N., Wegerif, R. And Dawes, L. (1999). Children's talk and the development of reasoning in the classroom. British Educational Research Journal, 25(1), 95-111.

Mercer, N. And Littleton, K. (2007). Dialogue and the development of children's thinking: A sociocultural approach London, Taylor and Francis.

Wellman, H. M., and Lagattuta, K. H. (2004). Theory of mind for learning and teaching: The nature and role of explanation. *Cognitive Development, 19*(4), 479-497.

Wood, D and O'Malley, C. (1996). Collaborative learning between peers. *Educational Psychology in Practice* 11(4), 4-9.

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