Module 13: ICT to enhance creativity and inquiry in early years science

Aims of the module:

- Introduce participants to the use of ICT in the context of inquiry-based and creative approaches to early years science education.
- Assist pre-school and primary school teachers in understanding the ICT contribution and its benefits in enhancing inquiry.
- Share with pre-school and primary school teachers' strategies in implementing ICT-based lessons and experiments.
- Increase teachers' awareness on different approaches in involving children in ICT assisted investigations.

Links to the Content Design Principles and Outcomes

9. Teacher education should enable teachers to make best use of and assess the various modes of expression and representation of science and mathematics learning to support inquiry and the development of creativity.

> 9.3 Teachers should be able to **select and use different approaches for and forms of recording children's ideas and learning** in science and mathematics at different stages of the learning process and for various purposes, including to support children's reflection and reasoning processes

17.Teacher education should address with teachers issues in ensuring rich provision, planning and use of resources (including digital resources) in and out of the classroom to support children's inquiry and creativity.

> 17.1 Teachers should be able **to organise and use materials** (including everyday materials), resources (**including ICT and natural resources) and equipment (including digital equipment and simple laboratory instruments)** in the classroom, school and wider environment, both indoors and out, to support independent inquiry and creativity.
>
> 17.2 Teachers should be able **to evaluate and select creativity enabling ICT resources** for children to use in their inquiry.

18. Teacher education should encourage and assess the development of teachers' literacy, numeracy and digital literacy skills through science and mathematics.

> 18.1 Teachers should develop their **literacy, numeracy and digital literacy skills through science** and mathematics.

Rationale for the module

Increasing recognition of the roles of digital technologies in enhancing inquiry and fostering creativity

The potential role of digital technologies in enhancing inquiry and fostering creativity is increasingly recognised. For example as noted in the Conceptual Framework adopted by the CEYS Project (Creative Little Scientists, 2012: 30):

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Science, mathematics and creativity have evolved through rapid advances in digital technologies, which are shaping new literacies. The introduction of the calculator for example, exemplifies how new devices can alter fundamental practices in areas such as science and mathematics… Other digital technologies are not only altering the demands involved in recording and calculating, but are also gradually removing the demands of collecting, organising and presenting data. Various authors (for example Wang et al, 2010) have claimed that **technology is able to support inquiry in a variety of ways, including data collection, stimulating questioning and supporting thinking.** For example, several recent projects have explored the use of mobile devices to support personal enquiry by allowing individuals to record and analyse information in the world around them (Anastopoulou et al, 2008). ..

In addition, **digital technologies can foster children's creativity**, for example, in gaming, in connecting with others and in content generation in particular (Craft, 2011). Children may use hand held as well as fixed console digital technology to collaborate with others in generating understandings and take digital images as a record of significant learning through their eyes. Thus **capabilities in science, mathematics and creativity are enabled through the rapid evolution of digital technologies but also to a degree demanded by these**. However, it is important to adopt a critical eye, as there are also arguments that technology might constrain children's interaction. Manches, for example, demonstrated how interaction through devices such as the mouse could limit the range of children's problem solving strategies in comparison to interaction with physical materials (Manches et al., 2010).

What the benefits are of using ICT in science teaching?

A 2006 review of studies related to the use of ICT in science teaching conducted by Hogarth et al. underlined the major benefits regarding the adoption of ICT in science teaching as follows:

- making students' learning more effective;
- increasing students' motivation;
- enhancing students' sense of achievement;
- providing students with access to richer sources of data and information;
- helping students to become autonomous learners;
- reducing pressure on students by letting them work at their own speed;
- enhancing students' literacy skills;
- making teachers take a fresh look at the way they teach;
- freeing teachers from administration to focus on students' learning.

What are the characteristics of effective pedagogy related to the use of ICT in the classroom?
The literature review of science education and the role of ICT conducted by Osborne and Hennessy (2003)suggests the following characteristics are important:

- ensuring that use is appropriate and 'adds value' to learning activities;
- building on teachers' existing practice and on pupils' prior conceptions;
- structuring activity while offering pupils some responsibility, choice and opportunities for active participation;

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- prompting pupils to think about underlying concepts and relationships, creating time for discussion, reasoning, analysis and reflection;
- focusing research tasks and developing skills for finding and critically analyzing information;
- linking ICT use to ongoing teaching and learning activities;
- exploiting the potential of whole class interactive teaching and encouraging pupils to share ideas and findings.

What are the challenges for practitioners?
As noted in the Conceptual Framework adopted by the CEYS Project (Creative Little Scientists, 2012) the majority of teachers argue technology has improved their teaching and that ICT can be used to enhance creativity and teachers. Teachers who have received ICT training are more likely to select interactive and social computing applications as contemporary tools for creative pedagogy. However whilst there is awareness of the significance of ICT across the curriculum, there is limited detailed reference to ICT either as a tool to support specific aspects of learning or the need to consider possible limitations of technology. Furthermore the potential of ICT to enable educational change towards a creative school environment is far from fully exploited, despite ICT being widely used in Initial Teacher Education to develop reflective practice. A number of common challenges are reported in introducing ICT in teaching and learning (for example European Schoolnet 2013) both teacher related barriers: such as lack of confidence and or negative attitudes to ICT, and school related factors including for example: resources, technical support, time, and provision of appropriate training.

Overview of the module

The module consists of the following activities:

1. **Introduction** - Aims and rationale for the module
2. **Sharing experiences of using ICT** to enhance science learning
3. **Practical activities**: using a range of ICT devices and applications to collect observations and measurements, model ideas/explanations, to control things
4. **Reflection on classroom examples**: ways in which ICT can enhance children's inquiry and creativity
5. **Role of the teacher** – planning and intervention to ensure that ICT enhances children's creative dispositions and scientific inquiry skills.
6. **Implications for future planning**
7. **Reflections** on module content and approaches

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Module at a glance

Time	Task	Materials	Grouping
00.00	**1.Introduction** - Aims and rationale for the module • Introducing definitions of creativity in learning and teaching from the Final report of the Creative Little Scientists project, 2014, adopted by the CEYS project. • Engagement activity: What do you think this is and why? – In pairs, participants are provided with one of the images (A to D) and asked to speculate what has been captured in the image and give reasons, using evidence in the image. The aim of this is not to come up with the correct answer, but to generate reasoned ideas. • Teachers share and compare ideas with the whole group. • Teachers reflect on the experience ○ What is your response to this activity? ○ What links can be made to creativity and inquiry? (Try to draw out the creative dispositions – wonder, curiosity, making connections etc)	Powerpoint presentation • Aims of the module • Comparing IBSE and CA Definitions of creativity Creative dispositions • Session rationale: Introducing ICT approaches and means of usage • Links to Content Design Principles and Outcomes • Module outline Handouts: Images A,B, C and D	Groups of 2 Whole group
00.20	**2.Sharing experiences of using ICT to enhance science learning** How have you used ICT to enhance learning in science? As an individual - Write down suggestions on separate post its and place on the sheet on the table or flipchart. As a group – See if you can sort these into to key scientific activities • Accessing information • Making observations and data capture • Handling information • Modelling and visualizing ideas • Communicating ideas. Feedback to the whole group: • Areas where you have lots of examples • Areas where you have few examples • Any challenges have you faced.	Powerpoint slides of the task Post its Pencils A2 sheet of paper/Flipchart	Individually Groups of 4 or 5 Whole group
00.40	**3.Practical activities:** using a range of ICT devices and applications to collect observations and measurements, model ideas/explanations, to control things 3a) *Whole group activity* Investigating making sounds using the datalogger and Data Harvest EasySense software or, if this is not available, use an online oscilloscope (See notes on PowerPoint for an example). Model asking 'what will happen if' questions and carry out short investigations to find answers. Discussion In what ways might this datalogging investigation • develop children's creative dispositions and • enhance their scientific inquiry skills? 3b) Activities in groups of 3 or 4 • Data loggers: measure temperature and light level to explore the classroom climate • USB microscope: look at a small insect, plant, crystals (sugar, salt,…) fabrics, skin, eyes teeth. in	Powerpoint slides of activity Computers or laptops or tablets. Data loggers USB microscope Sound sensor and data logger Camera or iPad Handouts: Datalogging activities How can ICT enhance the science curriculum?	Whole group Groups of 3 or 4

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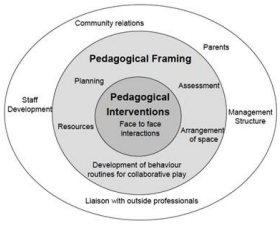
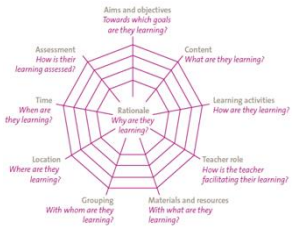
	order to observe texture, patterns, design etc. • Sound sensor and datalogger : explore sounds in the local surroundings • Using a camera/ iPad to capture change over time to allow comparisons: Milk Magic *http://www.sciencemuseum.org.uk/educators/classroom-resources/activities/kitchen_science*) Whole group discussion supported by the handout.		
01.10	**4. Reflection on classroom examples: ways in which ICT can enhance children's inquiry and creativity** The examples illustrate some uses of ICT in Science In what ways did they enhance or foster inquiry and creativity? In pairs: 1. Read through the classroom examples provided to gain an overview of the learning journey. 2. Then consider in what ways the use of ICT enhanced or fostered inquiry and creativity.	Powerpoint slides of activity Selected curriculum materials from CEYS: • Life cycle of a frog • Bees and their colonies • Materials: Investigating ideas with simulations • Study of simple physical phenomena	Groups of 2 Followed by whole class discussion.
01.40	**Coffee break**		
02.00	**5. Role of the teacher** – planning and intervening to ensure that ICT enhances children's creative dispositions and scientific inquiry skills. ○ Scan through the classroom example you have been given. ○ Please feed back to the group: • A brief summary of the ICT activity and the aspect(s) of scientific inquiry enhanced by the activity: (accessing information, making observations and data capture, handling information, modeling and visualizing ideas or communicating ideas). • How the teacher planned / intervened to ensure that ICT enhanced the development of children's creative dispositions and scientific inquiry skills.	Powerpoint slides of activity Classroom episodes from CLS: • Map symbols • Animal Fence • Playing with the microscope Handouts: *Pedagogical model* (Siraj-Blatchford et al 2002),  *Pedagogical synergies* between IBSE and CA. Episodes PDF	Work in 2 to discuss one example. Followed by feedback with whole class
02.20	**6. Implications for future planning** • In small groups, brainstorm **how you might use ICT in a future activity** linked to science that you will use back in school. • **Annotate the spider diagram** to show how your activity will develop children's creativity and enhance their inquiry skills. • **Present your ideas to the rest of the group** as a poster and explain what aspect of scientific inquiry was enhanced and how.	Powerpoint slides of task Handout: The vulnerable spider web (van den Akker 2007 p 39).  	Groups of 4/5 Followed by whole class discussion.

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		A1 worksheets for posters Pencils	
2.40	**7.Reflections on module content and approaches** • What impact do you expect this module will have on your future activities? • Identify one or two actions you will take as a result of your experiences on the module. • How far have the aims of the module been met? • Any further questions? Complete module evaluation	Powerpoint slides of activity Flip chart and pens to record feedback Evaluation form	Whole group
3.00	**End**		

Teacher education pedagogy

1. Introduction. This first activity indicates the aims and rationale for the module which draws on the use of ICT in science teaching in the context of inquiry-based teaching and learning and creativity development. At the beginning of the module, the definition of creativity proposed by the CLS project (2014) is discussed, as well as the links between Inquiry Based Science Education and Creative Approaches. The activity "What do you think this is and why?" supported by handouts draw out creative dispositions – wonder, curiosity, making connections, etc. and ways in which this encourages children to make observations, ask questions, make comparisons, suggest ideas etc.

2. Sharing experiences of using ICT to enhance science learning. The participants are encouraged to reflect on their own practice and find examples of using ICT to enhance learning in science. Further discussions (both in small groups and with the whole group) enable the crystallization of various areas for the use of ICT.

3. Practical activities: using a range of ICT devices and applications to collect observations and measurements. The initial activity is intended to model the use of datalogging, analysis of data, generation of questions to investigate. The whole group investigates making sounds using data logger and data Harvest EasySense software. Investigative questions are encouraged and then explored: 'what will happen if we sing quietly or clap our hands?', 'what will happen as we move the music source further away from the sensor?'
The online oscilloscope could also be used by participants to explore what happens if they make sounds in different ways http://www.physics-chemistry-interactive-flash-animation.com/electricity_electromagnetism_interactive/oscilloscope_description_tutorial_sounds_frequency.htm
A handout supporting the participants in doing the suggested activities is provided but alternative activities can be prepared using: data loggers and various sensors (temperature, light, sound, etc.), USB microscope, camera or iPad, etc.
The whole group discussion at the end of this activity concludes on the ways this datalogging investigation develop children's creative disposition and enhance their scientific inquiry skills. This discussion is supported by a handout which gives curriculum related examples of the different ways ICT can be used to enhance science learning.

4. Reflection on classroom examples: ways in which ICT can enhance children's inquiry and creativity. The examples of curriculum materials from the CEYS project provided in the slides are analyzed in pairs and the discussion with the whole class emphasize in what ways the examples enhance or foster inquiry and creativity.

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5.Role of the teacher. This activity is designed to encourage participants to reflect on the role of the teacher in ensuring that ICT enhanced the development of children's creative dispositions and scientific inquiry skills. Again, some of classroom examples are provided to teachers and in pairs they scan through one of them. The participants reflect on the role of the teacher. They share their insights and give a brief feedback on each example. The whole group discuss on different aspects of scientific inquiry enhanced by the activity (accessing information, making observations and data capture, handling information, modeling and visualizing ideas or communicating ideas). The discussion is supported by the pedagogical synergies between inquiry-based and creative approaches and the pedagogical model (Siraj-Blatchford et al 2002) – both part of the conceptual framework adopted by the CEYS project (Creative Little Scientists, 2012).

6. **Implications for future planning.** In this activity the implications for future planning are analyzed using the spider web model (van den Akker 2007 p 39) provided as handout. First, in groups of 4 or 5, the participants brainstorm how they might use ICT in a future activity linked to science and annotate the spider diagram to show how the activity will develop children's creativity and enhance their inquiry skills. Each group prepares a poster and presents it to the rest of the group, by explaining what aspect of scientific inquiry was enhanced and how.

7. Reflections on module content and approaches. During this phase teachers are encouraged to write feedback on the content as well as the process of the module. They reflect and identify one or two actions they will take as a result of the experiences on the module. A discussion with the whole group about the structure of the module can be a helpful reminder for the evaluation.

Background reading

The use of ICT in science teaching and its role in early years science

This module draws on both the Creative Little Scientists project findings in relation to the role of ICT in science teaching in early years. You may find it useful to provide opportunities for participants to become familiar with the content of other modules prior to this module. For example:

- **Module 4**: *Focus on inquiry-based science – link with creativity*, module highlighting the connection between IBSE and creativity;
- **Module 5**: *Focus on practical investigation which fosters creativity,* module exploring links between the scientific investigation and the creative approaches to science education;
- **Module 10**: *Focus on Cross curricular project work*, module of interest as it concerns science teaching in a cross curricular approach.

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

also 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.

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The Conceptual Framework (D2.2) for the CLS project, also available on the CLS website at http://www.creative-little-scientists.eu/content/deliverables, refers to the use of ICT in science teaching and learning. The full text can be found on the cited pages. Some extracts related to this subject are reproduced, for reader's convenience, below.

> "The Conceptual Framework highlights the need to use the knowledge of the curriculum and assessment of the CPD teacher as a starting point and for teachers to engage in collaborative learning communities, with professional development firmly set within a setting, as well as a more traditional approach of CPD where external experts introduce new and innovative ideas and act as a critical friend. The reviews also indicate the emergence of ICT based support has resulted in computer-supported collaborative learning (CSCL) in which resources and experience can be shared between settings." (pg. 12)
>
> "Referring to the perspectives of the teachers participating in the Connect-Me educational programme, virtual learning platforms and social media are conceptualized as enablers for the collegial sharing of self-directed, multi-purposed, convenient, and sustainable support. So far, the potential of ICT to enable educational change towards a creative school environment is far from fully exploited. However, CPD could draw upon examples of ICT being used in ITE to develop reflective practice." (pg. 83)
>
> "Based on interviews of EU teachers attending professional development courses, the OECD Talis survey (2009) on creative learning and innovative teaching found the majority of teachers argue technology has improved their teaching and that ICT can be used to enhance creativity. Data from this study showed that teachers who had received ICT training were more likely to select interactive and social computing applications as contemporary tools for more creative pedagogy." (pg. 88)

Research into effective use of ICT in science

Bingimlas, K.A., Barriers to the Successful Integration of ICT in Teaching and Learning Environments: A Review of the Literature, *EURASIA J. Math, Sci. & Techn. Education*, **5**(3), 235-245, 2009.

Bracewell, R.J., Le Maistre, C., Lajoie, S.P. and Breuleux, A., The role of the teacher in opening worlds of inquiry-driven learning with technology, In *Inquiry in education*, vol. II, Chapter 13, Shore, B.M., Aullus, M.W. nd Delcourt, M.A.B. (Eds.), Lawrence Erilbaum Associates, Inc. Publishers, New York, 2008.

British Educational Communications and Technology Agency (Becta), *What the research says about using ICT in science*, 2003.

European Schoolnet, *ICT in mathematics and science classes: use and obstacles*, Briefing Papers, ISSUE No.5 | November 2013.

Hogarth, S., Bennett, J., Lubben, F., Campbell, F. and Robinson, A., *ICT in science teaching. The effect of ICT teaching activities in science lessons on students' understanding of science ideas*, Institute of Education, University of London, 2006.

Osborne, J. and Hennessy. S. *Literature Review in Science Education and the Role of ICT: Promise, Problems and Future Directions*. A NESTA Futurelab Research report – report 6. 2003. <hal-00190441>.

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Songer, N.B., Digital resources versus cognitive tools: A discussion of learning science with technology, In *Research on science education*, Chapter 17, Abell, S.K. and Lederman, N.G. (Eds.), Lawrence Erilbaum Associates, Inc. Publishers, New York, 2007.

Guidance for teachers

Harlen, W. and Qualter, A., *The teaching of science in primary schools*, 4 th edition, David Fulton Publishers, Routledge, Oxon, 2007.

Hassard, J. and Dias, M., *The art of teaching science*, Routledge, New York, 2009.

Howe, A., Davis, D., McMahon, K., Towler, L., Collier, C. and Scott, T., *Science 5-11. A guide for teachers*. 2 nd edition, David Fulton Publishers, Routledge, Oxon, 2005.

Kibble, B. Using sensors to explore the environmental changes using a child's doll's house, and Using sensors to explore the environmental conditions, In *Effective use of ICT in science education*, Comenius project 226382-CP-1-20105-SK-Comenius-C21.

Suggested classroom examples for use during the module

The following classroom examples would act as useful starting points for discussion.

From the *Creative Little Scientists* project at http://www.creative-little-scientists.eu/content/deliverables.
Classroom Templates: FI Map symbols, FI Animal Fences, GR Playing with the microscope in Addendum to D5.3. These templates provide brief information. **For use in this module the full versions of the episodes from which these templates are provided in the module materials.**

Classroom episodes: PT Wolf, Sheep Cabbage, UKEn Habitats in D4.4 Appendix Selected Episodes of Practice

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

Title	Age group	Country
Life cycle of a frog	4-5	England
Bees and their colonies	4-5	Greece
Materials: Investigating ideas with simulations	5-6	England
Study of simple physical phenomena	5-6	Greece

However it is important to review and select examples appropriate to your context and audience. Other examples can be found on the CLS and CEYS websites.

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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
- Handouts
  - Task 1 – Sheets showing images A, B, C and D
  - Task 1 - Sheets showing definitions of creativity in early years science and Features of inquiry and creative dispositions - for reference during the session
  - Task 3 - Handouts: How can ICT enhance the science curriculum?
  - Task 3 - Datalogging activities
  - Task 5 - Sheet showing the pedagogical synergies between inquiry-based and creative approaches.
  - Task 5 - Sheet showing the pedagogical model (Siraj-Blatchford et al 2002).
  - Task 5 - Episodes for analysis
  - Task 6 - Sheet with the spider web model (van den Akker 2007 p 39)

Examples of classroom resources and equipment

Examples of Interactive Whiteboard use in early years Science teaching

- *Science for 5-7 years old* – http://www.topmarks.co.uk/Interactive.aspx?cat=62; http://www.topmarks.co.uk/Interactive.aspx?cat=90
- *Science for 7-11 years old* – http://www.topmarks.co.uk/Interactive. aspx?cat=68; http://www.topmarks.co.uk/Interactive.aspx?cat=96

Examples of Interactive Whiteboard use in early years Mathematics teaching

- *Math for 5-7 years olds* – http://www.topmarks.co.uk/Interactive.aspx?cat=8.
- *Math for 7-11 years olds* – http://www.topmarks.co.uk/Interactive.aspx?cat=20.

Examples of data logger use in early years Science teaching

- einstein™ Experiments and Activities – http://einsteinworld.com/home/elementary.html.
- CMA – http://cma-science.nl/homepage.
- PASCO Scienetific – https://www.pasco.com/prodCatalog/PS/PS-2934_elementary-school-science-standard-sensor-bun/index.cfm.

USB microscope:

https://nl.aliexpress.com/item/2016-Hot-Sale-New-Portable-1000x-Digital-USB-Microscope-Endoscope-Magnifier-Video-Camera-High-Quality-Microscopio/32751837600.html?source=%7Bifdyn%3Adyn%7D%7Bifpla%3Apla%7D%7Bifdbm%3ADBM&albch=DID%7D&src=google&acnt=494-037-6276&isdl=y&aff_short_key=UneMJZVf&albcp=658432961&albag=33762888219&slnk=&trgt=68416666751&plac=&crea=en32751837600&netw=g&device=c&mtctp=&gclid=CIDW2bbVktICFcad7Qod-BINYw

Beebot: https://www.bee-bot.us/

Clementoni robot:
http://www.clementoni.com/en/61298-mio-the-robot/

Apps:

- Skyview
- http://blog.iat.com/2014/12/29/25-stem-education-apps-you-need-in-2015/

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- http://www.educationalappstore.com/app/category/science-apps
- https://elearningindustry.com/15-free-science-ipad-apps-for-kids

Note: in accordance with the national curriculum in each country, examples of apps for iPhone and/or iPad can be selected, in the respective language.

References

Anastopoulou, S., Sharples, M., Wright, M., Martin, H., Benford, S., Crook, C., et al. (2008). *Learning 21st century science in context with mobile technologies*.

Capobianco, B., & Lehman, J. (2006). Integrating technology to foster inquiry in an elementary science methods course: An action research study of one teacher educator's initiatives in a PT3 project. *Journal of Computers in Mathematics and Science Teaching, 25*(2), 123-148.

CRAFT, A. 2011. *Creativity and education futures*. Stoke on Trent: Trentham Books

Manches, A., O'Malley, C., & Benford, S. (2010). The role of physical representations in solving number problems: A comparison of young children's use of physical and virtual materials. *Computers & Education, 54*(3), 622-640.

WANG, F., KINZIE, M. B., McGUIRE, P., and PAN, E. 2010. Applying Technology to Inquiry-Based Learning in Early Childhood Education. *Early Childhood Education Journal, 37*(5), 381-389.

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