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Understanding Early Childhood Science Education: Comparative Analysis of Australian and Finnish Curricula

Sari Havu-Nuutinen[1] · Sarika Kewalramani[2] · Nikolai Veresov[2] · Susanna Pöntinen[1] · Sini Kontkanen[1]

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Abstract
This research is a comparative study of Finnish and Australian science curricula in early childhood education (EC). The study aims to figure out the constructivist components of the science curriculum in two countries as well as locate the similarities and differences in the rationale and aims, contents, learning outcomes, learning activities, teacher's role and assessment. The curriculum analysis framework developed by Van den Akker (2003) was used as a methodological framework for the curricula analysis. Based on the theory-driven content analyses, findings show that both countries have several components of constructivist curriculum, but not always clearly focused on science education. The Australian Early Years Learning Framework (EYLF) integrates children's science learning within their five specific learning outcomes, whereas the Finnish national core curriculum for early childhood education and care has no defined learning outcomes in general. The Finnish curriculum more clearly than EYLF encompasses science and environmental education as a learning domain, within which children participate in targeted scientific activities to gain procedural knowledge in specific environmental-related concepts. More focus should be turned to the teachers' role and assessment, which are not determined in science context in both countries. This international comparative study calls for the need of a considered EC curriculum framework that more explicitly has science domains with specifically defined rationale, aims, content areas, learning outcomes and assessment criteria. The implications lie in providing early childhood educators with tangible and theoretically solid curriculum framework and resources in order to foster scientific thinking in young children.

Keywords Early childhood science education · Constructivist curriculum · Australian and Finnish curricula · Comparative study

✉ Sari Havu-Nuutinen
sari.havu–nuutinen@uef.fi

Extended author information available on the last page of the article

Introduction

Curriculum is best understood as a multi-faceted phenomenon. This paper draws from research that pose how important it is for teachers to be knowledgeable about the science curriculum and resources available to them in order to plan for all children's scientific inquiry and science-related learning outcomes (Fensham 1994, 2016; Kallery and Psillos 2004; Smith and Gunstone 2009) at the same time consideration of how science curricula prepare children for future learning and fulfil the components of scientific inquiry skills, which have been the highest priority recommendation issued by the Organization for Economic and Collaboration Development (OECD) recent research report (Mostafa and Pál 2018). Studies have shown how effective focus on early childhood science education produces better achievements in the later school years and how the elements (or prerequisites) of scientific thinking might emerge in the early years (Fleer 2013, 2018; Tao et al. 2012). However, the research focusing on the early childhood (EC) context has been limited, and there is a large variation in the role of science education in EC curriculum and related policy guidance (Garvis et al. 2013; Lehesvuori et al. 2017).

In this paper, as part of the current international study involving Australia and Finland EC science education contexts, we examine the science education curricula in the two countries in which there has been a refocus about science learning in the early years. The rationale for comparing the two countries comes from the 2015 Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) results, which paint a troubling picture of the state of science education in Australia. The results confirm that Australian students (both primary and secondary sector) still trail behind their peers, particularly those from East Asia and Finland, in science learning outcomes. Research is still pondering over the fact that Australia's 2015 Year 4 science score increased significantly from TIMSS 2011, but this was a significant decline from TIMSS 2007. On the other hand, despite rather good success of Finnish students in PISA evaluation, their placing in the competition has remarkably decreased since 2015 evaluation (OCED 2017). Such consistently disappointing findings have renewed calls for the Australian and Finnish school reform and prompted to consider within their country's EC contexts. In this paper, we draw attention to the constructivist components of learning (Branscombe et al. 2014) such as supporting thinking, children receiving the knowledge and skills which are needed in future societies (Karila et al. 2017), increasing problem-solving and how young children intentionally participate in investigations and develop inquiry dispositions (Australian Government of Department of Education and Training 2017). These components are continuously indicated as significant elements of developing EC science education (Flückiger et al. 2018) and holistic learning in EC more generally (Karila et al. 2017).

Considering that curriculum is an important part for steering of early science education and the key role it plays in setting out and implementing both national and international targets, this comparative analysis is a strategic and pedagogical tool to inform the policies for education provider's operation and the work carried out by the EC professionals (Australian Government of Department of Education and Training 2017; Fensham 2016; Karila et al. 2017; OCED 2017). In this comparative analysis of Australian and Finnish EC curricula, the rationale, aims and contents in the domains of science learning outcomes, learning activities, teacher's role and assessment for science education and societal purposes are discussed, thus developing an international debate (see, e.g. Havu-Nuutinen and Gatt 2012).

The Significance of Science Education in Early Childhood: a Constructivist Perspective

The period of early childhood education has a crucial role for children's learning experiences, and its impact for their later studies has been proved (Archer et al. 2014; Fleer 2013, 2018; Kennedy et al. 2014; Tao et al. 2012). The constructivist perspective for EC learning emphasizes that teachers within a play-based pedagogy know how to facilitate children's thinking and ideas in science topics as well as support problem-solving and learning in social interactions (Branscombe et al. 2014; Fleer 2013, 2018). Science education research has indicated that presenting children with the opportunities to engage with scientific content is significant (Fensham 2016; Kallery and Psillos 2004), and the methods as well as the environments of learning should be appropriate for the learners' age (Kallery 2011). In the constructivist perspective of EC education, teacher-centred instruction to guided discovery or students' inquiry learning is critical (Branscombe et al. 2014; Fensham 2016; Fleer 2018).

The recommendations offered to the future developments of EC science education relate to teachers' capacities to encourage children's conceptual understanding or engage children in science phenomena or carry out inquiry-based science investigations (Branscombe et al. 2014). The other challenge is that there are tensions in the early years teachers' understanding of science concepts (Hammer and He 2016; Harlen and Qualter 2014) or the nature of science (Duruk et al. 2019) and phenomena, and sometimes teachers can use anthropomorphism unconsciously that could limit children's conceptual learning (Kallery and Psillos 2004). Nonetheless, there are comparative studies that have found Romanian early years' teachers' perspectives of inquiry-based instruction (Havu-Nuutinen et al. 2017), indicating that the Romanian teachers' conceptualizations and confidence were pertinent for science teaching. The teachers relied more on children's learning outcomes to foster scientific inquiry dispositions in children. To encourage teachers to use conceptual and inquiry approaches more frequently that link to specific learning outcomes for children such as becoming confident and creative learners, there is a need to develop and strengthen the existing educational frameworks which support the teachers pedagogically. These can stem from curricula frameworks, not only at the Australian or Finnish level but also benchmarked, from country to country to probe into teachers' understanding of key contents, approaches and teaching methods rooted within the constructivist perspective in EC science education (Hamilton et al. 2019).

Garvis et al. (2013) have pointed out that the most common inhibitor to EC educators' implementation of science curriculum is the professional knowledge needed to link the local curriculum frameworks to create resources that demonstrate exemplar science teaching practices. Hence, introducing disciplinary content knowledge, prescribing pedagogical approaches, formalizing assessment and reporting suited for science education purposes can be seen as problematic. Slimilarly, Fluckiger and colleagues (2018) have suggested a way out here is to become aware of the importance of children experiencing positive transitions. More needs to be done to maintain the highly positive dispotitions towards science learning that children bring with them when they enter to school. motivating. As such, the role of educators is then to take greater notice of these perspectives and act upon them, hence the need for clear curriculum framework and guidelines to "sensitize" educators' pedagogical and instructional strategies revolving around science education. In this paper, we aim to describe the science contents and components of the Australian and Finnish EC curricula and identify the similarities and differences in policy guidance of teaching and learning in EC science education. Accordingly, the research questions were formulated:

1. What are constructivist perspectives of curriculum components of science education in the Australian and Finnish early childhood curricula?
2. What are the similarities and differences in the Australian and Finnish early childhood curricula for science education?

Early Childhood Curriculum Frameworks in Australia and Finland

EC curricula represent the initial foundation for science learning. Nonetheless, the curriculum as a document differs in several countries guiding teachers to plan, implement and assess their education in very different levels and from different ideologies (Smith and Gunstone 2009). Curriculum always sets the tracks for education by creating different values, discourses and cultures to implement it (Joseph 2011; Fensham 2016). Ironically, curricula development and reforms are more likely focused on political and ideological occurrences (Marsh and Willis 2007; Voogt and Roblin 2012). In this current comparative study, the curriculum paradigms (Joseph 2011) are commonly shared in relation to science learning highlighting the components of postmodernism and the constructivist perspective of EC curriculum (Branscombe et al. 2014). However, there is a need for the comparative curricula studies to strengthen the discussion of research-based developments of curricula in different cultural contexts. Although there are differences in the EC curricula and practices between countries (Inoue et al. 2017; Tao et al. 2012), only few comparative studies of EC science curricula exist (Hammer and He 2016; Marty et al. 2018).

Comparative studies considering curricula frameworks are needed to generate authentic data and analysis so that we learn from each other. For example, Inoue et al. (2017) in their comparative study of EC sustainability education have argued how the introduction of national guidelines was an important driver to enhance educators' understandings about sustainability within Japan, Australia and Korea and supported producing the material and approaches to support sustainability in the countries. Their international comparative study poses key recommendations—the need for targeted strategies for professional development in order to deepen educators' curricula understandings and improve practices for EC sustainability programs. And this can happen only when each national context is guided by country-specific policies, educational systems and curriculum guidelines.

Early Childhood Curriculum in Australia

In Australia, the first Early Years Learning Framework (EYLF) (birth to five years) was released in 2009, which formed the nationwide core curriculum guideline (Australian Government Department of Education and Training 2019). The current Australian science curriculum (towards Pre-Primary (Prep) and up to Grade 2) requires educators to support children building their independence in observing and sharing their discoveries. In line with this, the Australian Early Years Learning Framework (EYLF 2019) has recently proposed that the planning cycle structure supports educators' understanding of the continuity of learning in science concept areas from kindergarten onwards. The EYLF is based on the rationale that children's (0–5 years old) lives are characterized by belonging, being and becoming. As children participate in everyday life, they develop interests and construct their own identities and understandings of the world (Australian Government Department of Education and Training 2019).

There are five learning outcomes (LO) that supports children "have a strong sense of identity", "are connected with and contribute to their world", "have a strong sense of wellbeing", "are confident and involved learners" and "are effective communicators" (Australian Government Department of Education and Training 2019, p. 8). In particular, the EYLF conveys the highest expectations for all children's learning from birth to 5 years and through the transitions to formal schooling (Prep-Year 12), where there is a mandated Australian Science curriculum, separately for children age 6 years and above. Educators draw on a rich repertoire of pedagogical practices to promote children's learning by planning and implementing learning through play and intentional teaching. Although the purposes of science education have not been made explicit in the EYLF, the development of science skills in young children is intertwined within the five learning outcomes.

Early Childhood Curriculum in Finland

In Finland, the EC national core curriculum (Finnish National Agency for Education 2018) is an integrated curriculum which includes science education, but not as a separated subject. The curriculum defines the rationale and aims, content areas and the learning environment for four different learning areas: "Rich world of languages, Diverse forms of expression, Me and my community, Exploring and interacting with my environment, I grow, move and develop". Finnish EC education curriculum follows a holistic approach of education, instruction and care, and different emphases are given to different activities in different ages. In general, the Finnish national policy for EC education is very broad in nature, the specific, detailed aims and approaches being defined in local curricula and strategies created by teachers themselves. In addition, EC education and care lays the foundations for the children's transversal competences to develop their abilities to apply knowledge and skills, values and attitudes in various contexts (Finnish National Agency for Education 2018).

Method

In this study's comparative curricula analysis, we have applied the analytic document analysis method (Bowen 2009). Analytic document analysis is the examination of a text by the researcher according to various criteria, which requires data to be examined and interpreted in order to elicit meaning, gain understanding and develop empirical knowledge (Bowen 2009). In other words, researchers collect, record and document the phenomenon or the problem related to a study, encode and analyses them according to a certain criteria and system. In the current study, Van den Akker's curriculum design framework (2010, p. 181) has been applied from which the curriculum components of analyses were drawn. Van den Akker's framework (2010) introduces ten components to be analysed from the curricula (see also Marty et al. 2018). In this study, we have analysed six main components out of the ten. The selected ones (see Table 1) are essential to indicate the key components of the science curriculum from the constructivist perspective: rationale and vision, aims and objectives, contents, learning activities, teacher's role and assessment (see Table 1—Components of analyses and proposed questions for the analysis, Van den Akker 2010).

Table 1 Components of analyses and proposed questions for the analysis (Van den Akker 2010)

Curriculum component	Proposed questions for the analysis
Rationale and vision	What is the ultimate ideology of the education?
	What are the views indicated about the important of science learning outcomes?
Aims and objectives	What are the knowledge and skills targeted in teaching and learning?
	Which goals are children learning?
Contents	How science and digital learning is presented as learning domains and what are the key science and technology topics/strands/themes mentioned?
Learning activities	What kind of teaching and learning methods are used?
Teacher's role	How is the teacher facilitating learning?
Assessment	What are the areas targeted in assessment?
	What are the methods and approaches used in assessment?
	Ways to measure how far children's learning has progressed in the science domain?

Data Analysis

The research project was approved by the Monash University Human Research Ethics Committee and followed all the protocols inherent to the conduct of research in an ethical manner in both countries (Finnish National Board on Research Integrity TENK 2019). Data for this research are the national core curricula for EC education in Finland (Finnish National Agency for Education 2018) and in the EYLF in Australia (Australian Government Department of Education and Training 2019). The data are guiding documents of the national educational policy and present the ideology of EC education in the country (Joseph 2011). Both the curricula texts were read through by the researchers in each country to identify the key contents of science education in each selected component (see Table 1).

Key terms were initiated from the Australian and Finnish curricula text supported by research literature (Fleer 2013, 2018; Garvis et al. 2013; Inoue et al. 2017; Lehesvuori et al. 2017). The key terms were then also derived and linked to the elements of the constructivist curriculum framework (Branscombe et al. 2014). Van den Akker's (2010) framework was also used to categorize the initial curricula text analysis and then further root the analysis appropriately to the relevant components of the curriculum analysis framework.

We further adapted an approach from Lavrenteva and Orland-Barak (2015) for deducing the themes. The major themes were divided theoretically into the components of analyses (see Table 1) and further divided into pedagogical and instructional dimensions. The term pedagogical here refers to educators' intentional teaching actions and approaches that teachers implement during teaching of science. Pedagogical approaches may take place inside or outside the EC setting (e.g. acknowledging children's prior/everyday views of science concepts within child-centred inquiry). The term instructional here refers to educational strategies through which teaching and learning take place (e.g. inquiry- or phenomenon-based learning, scientific argumentation, experimentation, exploration, discovery learning). More generally, instructional strategies are used to cover the various aspects of sequencing and organizing science content, specifying learning activities and deciding how to deliver content and assessment (Lehesvuori et al. 2017). Although the identified themes are mainly based on Van den Akker's (2010) curricula components, it was imperative to analyse the data from the specific nature of EC pedagogical and instructional dimensions as well as the constructivist perspectives (Fleer 2013, 2018). Lastly, the authors confirmed the themes analysed from their respective curricula documents through a triangulation process (Bryman 2012).

Constructivist Perspectives of the Curricula Components

The curricula of both countries have several features in common, and both curricula have been designed according to the constructivist perspectives of EC, but clear differences can be identified in the emphasis of different components (see Table 2—Similarities and difference between Australian and Finnish EC science curricula).

Rationale and Vision for Science Education

Although the rationale and vision for science education have not been directly suggested, the Australian EYLF implicitly emphasizes within learning outcomes "develop dispositions for constructivist learning such as curiosity, creativity, and imagination and develop a range of skills and processes such as problem solving, enquiry, experimentation, hypothesizing,

Table 2 Similarities and differences between Australian and Finnish EC science curricula

Curriculum component	Finland	Australia
Rationale and vision	Socially and environmentally aware and responsible citizens	Focus on inquiry and experimentation
Aims and objectives	Focus on process skills	Focus on child's individual growth and development
Learning contents	More specific learning science concepts through learning in the immediate environment	No specific science concept or procedural knowledge
Learning activities	Focus on play for meaningful interactions and meaning making with environment	Focus on play for meaningful interactions in general with environment
Teacher's role	Plan intentionally play experiences, but not specifically related to science concepts	Plan intentionally play experiences, but not specifically related to science concepts
Assessment	No specific assessment criteria for science education. Assessment of the child's individual development is drawn up jointly by the staff and the child's parents	Focus resides particularly on documenting children's learning rather than assessing or reflecting along with children how to formulate future plans for scientific inquiry-oriented thinking skills

researching and investigating" (Australian Government Department of Education and Training 2019, p. 37). All children experience learning that is engaging and builds success for life. Fundamental to the EYLF, the ideology of education is a view of children's lives as characterized by belonging, being and becoming (Australian Government Department of Education and Training 2019). As children participate in everyday life, they develop interests and construct their own identities and understandings of the world. The EYLF suggests to shape children's identity, who they are and who they can become. It emphasizes that children learn to participate fully and actively in the society and promotes holistic development (Australian Government Department of Education and Training 2019, p.7).

In the Finnish national core curriculum for EC, the ultimate ideology of education focus is on sustainability, health, well-being and children's positive emotional learning experiences. Play is significant to promote children's holistic growth, development and learning in collaboration with their guardians. The main vision lies on the development of socially and environmentally aware and responsible citizens, to enrich children's understanding and interaction with phenomena in nature and technology, to develop more innovative thinkers and to develop important attitudes and dispositions as a foundation for future learning.

> […] Early childhood education is to guide children towards ways of living that promote health and well-being. Children are provided with opportunities for develop their emotions skills and aesthetic thinking […]" (Finnish National Agency for Education 2018, p.21)

Rationale and vision of both countries rely on the future learners' individual understanding of societal phenomena, but the Australian rationale emphasizes more on children's individual growth and success than the Finnish rationale. In addition, Australian curriculum does not provide clear rationale for contents of science; meanwhile, the Finnish document values sustainability and environmental awareness.

Aims and Objectives of Science Education

The main objective of both curricula is to support and promote the conditions for individual learning to develop children's self-care abilities and to prepare them for a higher level of education. Both countries do not specify explicit learning goals. The Australian framework expresses this as the aim that all young Australians become confident and successful learners. Moreover, objectives follow the constructivist approach emphasizing children as confident and creative individuals and active and informed citizens (see Branscombe et al. 2014). Play spaces in "children's natural environments such as plants, trees, sand, rocks, mud, water and other elements" have been suggested in the EYLF (Australian Government Department of Education and Training 2019, p. 18). There is a keen focus on "children communicate their own learning through connecting with people, place, technologies and natural and processed materials" (Australian Government Department of Education and Training 2019, p. 37).

Similarly, the Finnish curriculum aims to emphasize enriching children's understanding and interaction with natural phenomena and technology highlighting the aims to increase the children's knowledge construction and sense of their environment as the foundation for lifelong learning. Transversal competences have been highlighted where children observe, analyse and understand their local surroundings. Finnish national core curriculum also aims for children's multiliteracy where children are encouraged to explore, use and produce messages in different contexts and environments, including digital ones. The sustainable life and good nature relationships are one of the core aims.

> Multiliteracy is closely connected to thinking and learning skills. Children practice naming things and objects and learn different concepts. Children are encouraged to explore, use, and produce messages in different environments. (Finnish National Agency for Education 2018, p.26)

The curriculum highlights to aim for children's responsible citizenship, which learn from the environment, learn in the environment and act for the environment. In terms of cognitive learning, the EYLF focuses on inquiry and experimentation, while the Finnish one lays emphasis on the development of children's process skills.

Contents of Science Education

The Australian EYLF does not present science as a separate learning domain or learning contents. Particularly, elements of scientific inquiry and promoting science conceptual development remain absent in the Australian EYLF. On the other hand, there is more emphasis on "children's development of and thinking of concepts" (Australian Government Department of Education and Training 2019, p. 38), and children's learning of science knowledge and ideas are only integrated within children's active involvement with their environment, where children's understandings of *"*general*"* concepts, creative thinking and inquiry processes are developed.

Within the Finnish EC core curriculum, main content of science is integrated in the learning area: "I grow, move and develop". Specifically, environmental education is presented as a formal learning domain, in which the children's knowledge and understanding of the basic scientific concepts and processes are fostered. For instance, while exploring and interacting with their environment, children develop competence of naming phenomena and using different concepts, which promotes their knowledge and multiliteracy. Children learn to use science concepts connected to the nature such as practice in identifying plant and animal species.

Learning Activities

In both the countries, the learning activities are framed by play-based pedagogy, *and* integrated teaching and learning approaches are recommended to use. In Australia, play is *an* approach to initiate activities emerging from children's own ideas and "participate in a variety of rich and meaningful inquiry-based experiences" (Australian Government Department of Education and Training 2019, p. 20) to investigate and solve problems. More emphasis is laid on the use of creative arts such as drawing, music, drama and storytelling. Activities mainly promote children's literacy and language development, and science is *"*only*"* about the world around them. No activities specific to authentic explorations of everyday science phenomena and concepts that might be related to *p*hysical, *c*hemical, *b*iological and Earth or environmental sciences are mentioned in the EYLF. More emphasis is on "numeracy skills acquisition while children make predictions and generalizations about their daily activities and explore aspects of the natural world and environments" (Australian Government Department of Education and Training 2019, p. 38). In doing so, emphasis is on "children using patterns they generate or identify and communicate these using mathematical language and symbols" (Australian Government Department of Education and Training 2019, p. 38). There are no clear links to science learning activities that promote scientific thinking neither do the practice principles for educators promote the acquisition of such science skills for children.

In contrast, the Finnish curriculum explicitly provides a guide for incorporating several learning activities which fosters children's engagement and participation with environmental activities. The document hihglight the children's exploration and interaction with their environment with using different senses and in different seasons. In addition, the children should observe natural phenomena such as the weather or a plant growing and describe what they see, ask questions about objects, organisms, and events in the environment. All emotionally enriched activities are indicated appropriate. However, emphasis on creativity and scientific inquiry is not explicitly apparent in either of Australian or Finnish curricula documents.

Teacher's Role

Teacher's role in curriculum is introduced similarly in both countries. However, the teacher's role is not specifically determined in relation to science teaching and learning, but their responsibility is defined to organize learning environments through play-based activities. Within the Australian EYLF, teacher's pedagogy involves intentionally constructing curriculum and learning experiences relevant to children in their local context. Emphasis is not so much on the planning of teacher-directed or explicit science-related experiences, rather to gradually expand children's knowledge and understanding of the natural world (Australian Government Department of Education and Training 2019, p. 16). Teachers actively promote children's learning through worthwhile and challenging experiences and interactions that foster high-level thinking skills. Teachers are asked to use strategies which foster shared thinking and problem-solving to extend children's thinking and learning. The EYLF underpins pedagogical practices that require teachers to intentionally plan and model "inquiry processes, including wonder, curiosity and imagination, get children to try new ideas and take on challenges" (Australian Government Department of Education and Training 2019, p. 37). Although inquiry approaches are mentioned relating to achieving clear and meaningful learning outcomes for children as confident learners, the science learning outcomes remain absent in the EYLF.

Similarly, Finnish teachers take charge of preparing and evaluating the implementation of the child's individual learning plan and the daily activities. Their role as a "guide" is to support the children in their curiosity and challenge their thinking. As a pedagogical expert, teacher's focus is on children's affective learning in the sense that they support the child's individual learning process and motivation to form opinions and evaluate critically, think and act in a sustainable manner. Teachers work in a multiprofessional group to provide the maximum support for each child.

Assessment

In the Australian EYLF, one of the practice principles is that "teachers plan effectively for children's current and future learning, communicate about children's learning and progress, determine the extent to which all children are progressing towards realizing learning outcomes and if not, what might be impeding their progress" (Australian Government Department of Education and Training 2019, p.19). Since the EYLF does not specify science learning outcomes, the focus resides particularly on documenting children's learning rather than reviewing or reflecting along with children, how to formulate future plans for scientific inquiry-oriented thinking skills or conceptual understandings altogether are missing. Instead, as a part of supporting children's future learning, there is mention of the "cognitive environment and the need for practising basic skills" (Australian Government Department of Education and Training 2019, p. 10), but no clear purpose of assessing science learning such as inquiry skills or science literacy skills.

In Finland, the learning process and its outcomes are not assessed through summative or formative assessment criteria (Finnish National Agency for Education 2018). In relation to science education learning outcomes, there are no specific assessment criteria for assessing, for example, child's scientific inquiry development. Educators jointly make judgements about children's individual development in partnership with the child's parents. Educators reflect on their planning and teaching, firstly to map and then to document the child's individual learning and experiences, strengths and needs, which are considered as the child transitions into formal schooling contexts. The child's learning and development plan takes into consideration the dimensions through which the child's development can be supported in the future and consequently monitored and regularly assessed. The assessment of skills and conceptual knowledge is kept to the very minimum. Educators rely on everyday observations and interactions and reflective discussions with parents and children as the core forms of assessment (Finnish National Agency for Education 2018.)

> Pedagogical documentation is essential working approach in planning, implementing evaluating and developing early childhood education and care. This documentation is continuous process where observations documents and their interpretation in interaction create an understanding of pedagogical activity. Pedagogical documentation enables the participation of children and guardians in evaluating, planning and developing activities. (Finnish National Agency for Education 2018, p. 37)

In both the Australian and Finnish curricula, assessment for children's science learning remains unclear as there are no specific directions for interpreting whether the learning needs to be evaluated. Pedagogical documentation is the only apparent and essential working approach in planning, implementing, evaluating and developing holistic EC education and care in both Australia and Finland.

Discussion and Conclusions

This study analysed the science contents and components of the Australian and Finnish EC curricula and investigated the below research questions:

1. What are constructivist perspectives of curriculum components of science education in the Australian and Finnish early childhood curricula?
2. What are the similarities and differences in the Australian and Finnish early childhood curricula for science education?

Although it may seem that the national curricula frameworks are not the best sources for studies of pedagogy, curriculum still orients teachers for planning and teaching (Branscombe et al. 2014; Van den Akker 2003, 2010). The findings show that the Australian and Finnish curricula texts are situated in their frameworks as constructivist perspectives for early childhood science education (Branscombe et al. 2014). The curricula analysis strongly follows the components, which have been indicated significant by seminal science education researchers (Fensham 1994, 2016; Fleer 2013, 2018). The rationale is supported by constructivist perspectives as it provides opportunities for the children as individuals to act in their neighbourhood environments and engage and participate actively in learning situations shared with others. However, the analysis indicates that learning outcomes have not been precisely mentioned for children's scientific inquiry and conceptual understanding. If such learning outcomes and related learning activities for children's scientific inquiry and conceptual understanding do not become clear for EC educators, it can be confusing and leaves room for misinterpretation (Hammer and He 2016; Inoue et al. 2017). EC teachers' conceptual understanding and self-confidence in adopting intentional teaching strategies for science are often limited (Duruk et al. 2019; Fleer 2013; Kennedy et al. 2014); hence, the curriculum framework should provide support for the teachers by indicating clearly and widely the content areas and targeted learning outcomes. Even if the children are the centre of the constructivist curriculum (Branscombe et al. 2014), they are guided by their teachers towards achieving the learning goals. Standardization of nomenclature for age appropriate science learning should also be promoted to support teachers' understanding and teaching of the key terms (Inoue et al. 2017).

Contradictory to previous curriculum analysis studies (Fensham 2016), both analysed curricula do not emphasize on guided discovery learning in science education and the nature of science, which has been deemed significant for developing a continuum for science teaching and learning. As such, the current curricula analysis continues the debate elevated by Fensham (2016), suggesting that we set out the rich diversity for science education in curricula documents and reorder EC curricula so that educators can adopt the constructivist approach to engage children more actively in science education and societal issues (Fensham 1994, 2016; Rennie 2006; Saunders and Rennie 2011). We recommend that further studies should take into consideration pedagogical strategies that scaffold teachers in introducing science concepts to children in age appropriate and authentic ways (Saunders and Rennie 2011). Future curricula frameworks and guidelines must postulate science learning as "real world" learning and be holistic rather than a traditional disciplinary or technical view of science-based concepts (Rennie 2006).

While Australia has a dedicated curriculum in science and subjects/domains for children age 6–8 years old and above, science has the status of being a school subject with specifically defined content areas, aims and objectives including assessment outcomes. Although this study showed how Finnish and Australian EC science learning and teaching delivery are done in an integrated way, it would be necessary in curricula to explicitly describe the pedagogical ways and aims for educators to create the conditions for enabling children's scientific thinking skills, guide children to learn argumentation and start to become aware of science contents that exist in natural phenomena (Fensham 2016).

Drawing from the constructivist curriculum framework (Branscombe et al. 2014) and the challenges recognized in previous EC science studies (Fensham 2016; Garvis et al. 2013; Kallery and Psillos 2004; Smith and Gunstone 2009), we recommend that a clarification for science education contents is required. We suggest encompassing the definition of creativity and scientific inquiry, which are naturally manifested in children's holistic learning and cultivating positive dispositions towards science learning (Flückiger et al. 2018; Saunders and Rennie 2011). Curriculum needs to strengthen the constructivist aspects of science education and provide EC educators with professional learning and tangible resources including exemplars of inquiry-based experiences, so they feel confident and armed to foster these science learning skills with young children. It may also be possible to introduce interdisciplinary themes that can be addressed within and across learning and development areas in EC in general. Although we suggest strengthening the science contents and learning outcomes to become more visible in EC curricula, we do not aim that EC science education should be a "pure" science subject in EC education. As presented in the current curricula, science teaching and learning must be integrated and holistically implemented with socially enhanced play-based activities, but having clear aims and goals is equally essential. Curriculum should support especially the teachers to recognize the essential contents for supporting and creating science learning for the children. Curriculum can also include specific science-related skills such as the development of scientific inquiry, questioning of scientific phenomena and the ability to link them to everyday events. Again, this study is not suggesting schoolification (see Clausen 2015) as the process of formal early childhood education becoming more school-like and subject-oriented, but for developing EC science education, the importance of contents and purposes in scientific inquiry should be indicated. We are rather suggesting that to make twenty-first century children capitalized, the approach taken by policy and curriculum stakeholders should involve exposing children to the "culture" of learning science-related skills and engagement in scientific phenomena, thus enriching their science capital (Smith and Gunstone 2009; Archer et al. 2014).

As a sum, the study proposes the following elaborations to meet more precisely the current needs of science education: aims and objectives should be formulated as introducing the elements of science knowledge to children; teacher's role is to be active participants in children's play and incorporate the elements of scientific knowledge and understanding through play; the content and learning activities should be created on the child's existing spontaneous concepts in order to enrich and improve them; and finally, the assessments need to be (re)designed as tools to support the development of children's scientific inquiry and creativity.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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Affiliations

Sari Havu-Nuutinen [1] · Sarika Kewalramani [2] · Nikolai Veresov [2] · Susanna Pöntinen [1] · Sini Kontkanen [1]

[1] School of Applied Educational Science and Teacher Education, University of Eastern Finland, 80100 Joensuu, Finland

[2] Faculty of Education, Monash University, Melbourne, Australia