This is the published version of a paper published in *Education Inquiry*.

Citation for the original published paper (version of record):

Children's learning for a sustainable society: influences from home and preschool.
*Education Inquiry*, 8(2): 151-172
https://doi.org/10.1080/20004508.2017.1290915

Access to the published version may require subscription.

N.B. When citing this work, cite the original published paper.

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Children's Learning for a Sustainable Society: Influences from Home and Preschool

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To cite this article: Farhana Borg, Mikael Winberg & Monika Vinterek (2017) Children's Learning for a Sustainable Society: Influences from Home and Preschool, Education Inquiry, 8:2, 151-172, DOI: 10.1080/20004508.2017.1290915

To link to this article: http://dx.doi.org/10.1080/20004508.2017.1290915

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Published online: 20 Feb 2017.

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ABSTRACT

Although parents and preschool play important roles in developing children’s behavior and attitudes, little is known about their influences on children’s learning of environmental, social and economic aspects of sustainability. This study investigated the influences of home- and preschool-related practices and factors on children’s declarative and functional knowledge of sustainability issues, and the extent to which eco-certified preschools promote beneficial practices. ‘Eco-certified preschools’ refers to schools that explicitly work with education for sustainability. Children (n=53), aged five to six years, and the directors (n=7) at six eco-certified and six non-eco-certified preschools were interviewed, while guardians (n=89) and teachers (n=74) filled out questionnaires. Children’s responses were categorized and classified using SOLO Taxonomy. Multivariate analyses were performed in SIMCA P + 14. The findings indicate a positive relationship between children’s declarative and functional knowledge of sustainability issues and the involvement of teachers and guardians in sustainability-related discussions and activities. Teachers’ verbal interaction with children about sustainability issues, and the perceived high value of these issues among teachers and directors seem to be more beneficial for children’s declarative knowledge than their functional knowledge. No statistically significant differences between eco- and non-eco-certified preschools in terms of children’s declarative and functional knowledge were found.

Introduction

Children are surrounded by many influential role models in society – for example, parents, siblings, teachers, friends, and TV characters – and their learning occurs through being explicitly taught by others, through direct observation, through participation in activities and through sharing information from books (Bandura, 1977; Corsaro, Molinari & Rosier, 2002). Although evidence from several studies on various topics supports this claim (Anders et al., 2012; Grodzieska-Jurczak, Stepska, Nieszporek, & Bryda, 2006; Musser & Diamond, 1999; Webley & Nyhus, 2006), little has been done to explore the influence of parents and teachers on developing children’s understanding and practices in terms of sustainability. This knowledge is important to improve
practices related to education for sustainability (EfS) at the preschool level and to facilitate evidence-based policymaking.

The importance of integrating EfS in early childhood education has been emphasized since the concept of sustainable development was introduced in Brundtland’s report in 1987 (Davis, 2015; Pramling Samuelsson, 2011; Siraj-Blatchford, Smith, & Pramling Samuelsson, 2010). High-quality early childhood education is effective in developing young children’s attitudes and forming their behaviors (Siraj-Blatchford, Taggart, Sylva, Sammons, & Melhuish, 2008). Moreover, it has positive effects on children’s well-being, health, and intellectual and social behavioral development especially for those children from disadvantaged backgrounds (Muennig, Robertson, Johnson, Campbell, Pungello & Neidell, 2011; Siraj-Blatchford et al., 2008). A central starting point in EfS is building on children’s participation, and viewing them as active agents and stakeholders for the future (Gothenburg Environmental Centre, 2010). Parents’ beliefs and their associated behaviors have also been found to influence children’s beliefs and behaviors (Musser & Diamond, 1999; Sigel, Stinson, & Flaugher, 1991). Social learning - “a transitional and transformative process that can help create the systemic changes needed to meet the challenge of sustainability” - is also considered to be a powerful tool in the development of a sustainable world (Wals & van der Leij, 2007, p. 32).

**Sustainable development and global commitments**

Sustainable development is defined as a “development that meets the needs of the present without compromising the ability of future generations to meet their needs”, and has three intertwined dimensions: environmental, social and economic (WCED, 1987, p. 43). The environmental dimension of sustainable development includes, for example, natural resources, climate change, rural development, sustainable urbanization and disaster prevention and mitigation; the social dimension addresses, for example, human rights, peace and human security, gender equality, cultural diversity and intercultural understanding, health, HIV/AIDS and governance; and the economic dimension of sustainable development refers to, for example, poverty reduction, corporate responsibility and accountability, and the market economy (UNESCO, 2006). In this paper, the terms ‘sustainable development’ and ‘sustainability’ are used synonymously, as they both are widely recognized in this field.

To promote education for sustainable development within all areas of teaching and learning, the Decade of Education for Sustainable Development was declared from 2005 to 2014 (UNESCO, 2005). The decade has now ended and a new plan of action was outlined for people, planet and prosperity in the 2030 agenda for sustainable development (UN, 2015). This plan sets 17 sustainable development goals, including quality education, to ensure that all learners acquire the knowledge and skills necessary to promote sustainability by 2030.

**Early childhood education for sustainability in Sweden**

In Sweden, preschool refers to early childhood education and care for children until they start school, which normally is at age six or seven. Although the term sustainable development is not explicitly used in the preschool curriculum, the environmental,
social and economic dimensions of sustainability are included in the document as goals to strive for (Engdahl & Ärlemalm-Hagsér, 2014). Preschools are expected to include educational activities highlighting nature and environment, as well as to work with democratic values as a foundation for learning and social interactions (Skolverket, 2011). EfS is an extension of the earlier environmental and social traditions and aims to improve the quality of life of Swedish citizens (Engdahl & Ärlemalm-Hagsér, 2014).

According to the Swedish National Agency for Education (SNAE), sustainability is about shared responsibility and solidarity between generations, genders, communities and countries (Skolverket, 2016). All preschools should strive to ensure that each child develops respect for all forms of life and cares for the surrounding environment (Skolverket, 2011). To promote EfS in all aspects of education and learning, the SNAE can certify preschools with a ‘Diploma of Excellence in Sustainability’ if they follow a number of sustainability-related criteria, which include systematic quality work of educational management and educational work following laws and regulations that are relevant to education for sustainability (SKOLFS, 2009:19). The criteria include the need for preschool personnel and children to work together to plan, implement, follow up and evaluate the learning for sustainable development. Children are expected to have an active role and a real influence on their learning based on their abilities. This certification is renewed every three years if the preschool reapplies for it. SNAE has certified 248 preschools for their work with EfS as ‘Preschool for Sustainable Development’ (Skolverket, 2014).

Preschools can also be certified with ‘Green Flag’ certification by the Keep Sweden Tidy Foundation, which is part of the eco-school program of the Foundation for Environmental Education (FEE). In Sweden the ‘Green Flag’ certification has existed since 1996 and approximately 1600 preschools are certified with a ‘Green Flag’ (HSR, 2016). The Keep Sweden Tidy Foundation supports preschools in their systematic work with EfS for active and long-term sustainable development. Participating preschools write action plans for their educational work, which are submitted to the foundation and evaluated periodically. The staff can also participate in in-service training on EfS to gain ideas about how to implement EfS at their preschools. Although this FEE eco-school program is coordinated internationally, the member nations are free to design their programs according to their own needs (Henderson & Tilbury, 2004).

EfS is concerned with learning for sustainable development rather than learning about sustainable development, which means that a school is supposed to incorporate teaching and learning for sustainability “not only through aspects of the curriculum, but also through sustainable school operations such as integrated governance, stakeholder and community involvement, long-term planning, and sustainability monitoring and evaluation” (Hargreaves, 2008, p. 1). As the eco-preschools work explicitly with EfS, people may expect some positive outcomes of EfS programs in terms of developing children’s understanding, attitudes and practices of sustainability issues compared with those of non-eco-certified preschools (Olsson, Gericke, & Chang Rundgren, 2015). In this text, preschools that are certified with ‘Green Flag’ or ‘Preschool for Sustainable Development’ are called ‘eco-certified’ preschools.

Despite different types of certifications being granted, very little is known about the effect of eco-certification and what types of educational activities are important to help developing children’s understanding, attitudes and practices of environmental and
sustainability-related issues. The Education 2030 Framework for Action mentions that the effect of education policies should be evaluated by all countries at the national level to achieve the Education 2030 targets, and that policies "must build on monitoring results and research findings to ensure effective evidence-based decisions and results-oriented programs" (UNESCO, 2016, p. 38). In fact, there is a general lack of research on and evaluations of the effectiveness of EfS programs in whole-school sustainability programs globally (Henderson & Tilbury, 2004).

**Purpose and research questions**

The purpose of this study was to investigate the relative influences of home- and preschool-related practices and factors on children’s declarative (understanding) and functional (practices) knowledge of sustainability issues and the extent to which eco-certified preschool promotes beneficial practices, if any. In this text, the term ‘declarative knowledge’ refers to children’s description of what they understand based on their expression in words, writing or drawings, whereas ‘functional knowledge’ refers to what children are able to do or perform based on their understanding (Biggs & Tang, 2011; Hattie & Yates, 2013; Hook, Wall, & Manger, 2015). The following research questions were posed:

- What is the relative importance of the factors (home and preschool) measured in this study for explaining children’s declarative knowledge of sustainability issues?
- Which effective practices at home and at preschool can promote children’s functional knowledge of sustainability issues?
- What differences can be found between eco-certified and non-eco-certified preschools with regards to educational practices, as measured in this study?

The term knowledge, in this text, does not refer to the theory of knowledge, which is often associated with the notion of truth (von Glasersfeld, 1990); rather, it refers to the descriptions of children’s self-reported ideas, thoughts and views of issues related to their everyday lives.

**Methods**

**Design**

This study combined both qualitative and quantitative data, which were collected from preschool children, their guardians, teachers and directors (see Table 1). Purposive sampling was used to include equal numbers of eco-certified and non-eco-certified preschools in the study. This would allow for comparisons of relative influences of home- and preschool-related practices and factors on children’s declarative and functional knowledge of sustainability issues, and to investigate if eco-certification is associated with any beneficial preschool educational practices. However, as eco-certified preschools were not situated in all municipalities in Sweden, and not all preschools were interested in participating in the study, it was not possible to involve eco-certified...
and non-eco-certified schools from the same municipalities. To be included in the study each preschool should have at least three final-year children.

In this text, both the ‘Green Flag’ (n = 4) and the ‘Preschool for Sustainable Development’ (n = 2) are presented as ‘eco-certified’ preschool. The preschools were located in six municipalities in two counties in Sweden. All interviews were conducted in Swedish and most parts were transcribed and then translated into English. The study was conducted in Sweden between February and September 2015, with ethical approval granted by the Umeå Regional Ethical Review Board, Sweden. All participation was voluntary and could be discontinued at any time without any reason being given. The integrity of participants was taken into consideration while conducting and performing the study, e.g. by anonymizing all data once the links between data from the different sources had been established.

**Data-collection process**

**Children**

All participating children (n = 53) were between five and six years old and were enrolled in the final year of preschool. Each child was interviewed individually and, if permitted by guardians and the children themselves, the interviews were audio-taped so that note-taking could be avoided during the conversation. Guardians of 49 children granted permission for audio-recording, whereas guardians of four children did not. Each interview took 15 to 25 minutes. Four children were interviewed in the presence of their teachers as per their own wishes.

**Guardians**

Either one or both guardians (mother n = 48 and father n = 41) of each child participated in a survey. For this study the term guardian is used due to the fact that some children might live at foster homes with their guardians instead of their biological parents. Regardless of whether the guardians are biological parents or not, in this study they are referred to as mothers and fathers. A letter with information about the study was sent to both guardians through the teacher(s) at the unit where the child was

---

Table 1. Overview of participating children, guardians, teachers, directors and preschools.

<table>
<thead>
<tr>
<th></th>
<th>Eco-certified</th>
<th>Non-eco-certified</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preschools</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Children</td>
<td>38</td>
<td>15</td>
<td>53</td>
</tr>
<tr>
<td>Girls</td>
<td>23 (60.5%)</td>
<td>6 (40.0%)</td>
<td>29 (54.7%)</td>
</tr>
<tr>
<td>Boys</td>
<td>15 (49.5%)</td>
<td>9 (60%)</td>
<td>24 (45.3%)</td>
</tr>
<tr>
<td>Guardians</td>
<td>64</td>
<td>25</td>
<td>89</td>
</tr>
<tr>
<td>Women</td>
<td>34 (56.0%)</td>
<td>14 (53.1%)</td>
<td>48 (53.9%)</td>
</tr>
<tr>
<td>Men</td>
<td>30 (44%)</td>
<td>11 (46.9%)</td>
<td>41 (46.1%)</td>
</tr>
<tr>
<td>Teachers</td>
<td>43</td>
<td>31</td>
<td>74</td>
</tr>
<tr>
<td>Women</td>
<td>41 (95.3%)</td>
<td>29 (93.5%)</td>
<td>70 (94.6%)</td>
</tr>
<tr>
<td>Men</td>
<td>2 (4.7%)</td>
<td>2 (6.5%)</td>
<td>4 (5.4%)</td>
</tr>
<tr>
<td>Directors</td>
<td>4*</td>
<td>4*</td>
<td>7</td>
</tr>
<tr>
<td>Women</td>
<td>4* (100%)</td>
<td>4* (100%)</td>
<td>7 (100%)</td>
</tr>
<tr>
<td>Men</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

*One director was responsible for both an eco-certified and a non-eco-certified preschool."
enrolled. Each guardian was asked to complete the survey questionnaire separately: this required 10 to 15 minutes.

**Teachers**
This study uses the term teachers to address both qualified teachers and child attendants. A survey among teachers (qualified teachers n = 41 and child attendants n = 33) was conducted. One of the qualified teachers was male and one of the respondents did not specify either his/her sex or position (qualified teacher or child attendant). Teachers who had been employed at least six months at a participating preschool were eligible for the study. Teachers who worked at units with children younger than three and who did not work with final-year preschool children were not included. The survey questionnaire required 10 to 15 minutes to complete. The answers from the teachers at the respective preschool were averaged on item level before further analyses.

**Directors**
All directors (n = 7) of 12 participating preschools were interviewed individually. Four of the directors were responsible for at least one preschool with eco-certification, whereas three of the directors were responsible for non-eco-certified preschools. Five directors were interviewed alone, while two were interviewed in the presence of two qualified teachers who led educational work at the preschools. Each interview lasted between 25 and 45 minutes. After permission was sought from participants, all interviews were audio-recorded and totaled 203 minutes. The venues for the interviews were chosen by the directors themselves.

**Data-collection instruments**
In order to develop the data-collection instruments for children, their guardians, teachers and directors, a number of studies were reviewed; however, hardly any research was found that focused on developing instruments that addressed all three dimensions – environmental, social and economic – of sustainable development. The following steps were taken to develop instruments that suit the purpose of this study:

**Operationalization of the concept of sustainable development**
Using the three-interlocking-circle framework (Elliot, 2013), which portrays the equal importance and interdependency of the environmental, social and economic dimensions of sustainable development, the concept was operationalized into four themes: financial affordability, resource sharing, recycling and transport use (see Figure 1). Sustainable development is concerned with human to human relations and the relations humans have with the surrounding environment; therefore, it would have been possible to select a wide range of themes. However, as this study involved preschool children in a preschool context with limited time available for this study, the themes to be included had to be limited. The four mentioned themes were selected based on their relevance to sustainable development, their appropriateness in relation to the curriculum, their assumed relevance to children and their comprehensibility from the child’s perspective.
Sharing resources with others is a social aspect of living together but it also includes an economic aspect, which can be understood by children from earlier experiences. To operationalize the concept of economics for young children, it was necessary to find out what the notion of economy means to them. Webley (2005, p. 43) has suggested that when "considering children’s understanding of economics, we should not only be concerned with the cash economy, but also need to consider their understanding of swapping, doing chores, and gift-giving.” In this study, ‘candies’ and ‘toys’ are used as examples of children’s economy along with cash, as ‘candies’ and ‘toys’ are considered to be kinds of possessions that they frequently deal with in their daily lives, whether at home, at preschool or in the playground, and about which they often have decision-making rights (Näsman & von Gerber, 2002; Webley 2005).

Pramling Samuelsson (2011) argued that environmental issues have always been an integral part of children’s lives and that, therefore, these issues can be used as a starting point for their learning. It was assumed that young children have used different modes of transport. The transport theme was therefore chosen to represent the environmental dimension of sustainability, as different modes of transport have various effects on the environment. As a way of dealing with the waste of natural resources, recycling was also selected to represent the environmental dimension of sustainability. In addition to preserving nature by reusing or composting waste, recycling includes an economic dimension of sustainability by saving money. The recycling theme was used to create opportunities for children to be involved in playful recycling activities as well as to demonstrate their functional knowledge. All four themes are interconnected and do not therefore represent just one of the dimensions of sustainability separately.

**Semi-structured interview questions for children**

Semi-structured interviews were conducted with closed- and open-ended questions (see an excerpt Figure 2), guided by Bruner’s (1966) three modes of representation, where he argues that children aged one to six construct their knowledge by organizing and categorizing information through Iconic representation in which information is stored...
visually in the form of images and diagrams. A set of colored illustrations was developed and used as artefacts during the interviews; a literature review showed that such artefacts had been useful in previous studies (Clark, 2007). The semi-structured instrument included questions about children’s background (sex, age, preschool profile), their views of other children’s financial means, their willingness to share candies with friends, their knowledge of recycling different items, and their understanding of the impact of using different modes of transport on the environment.

Considering the importance of play as a natural component of children’s lives and as a basis for making children interested in particular phenomena (Pramling Samuelsson & Asplund Carlsson, 2008; Pramling Samuelsson & Pramling, 2013), the interviewer (first author) used a cuddly puppet, some toys, and a special sitting mat with a picture of two puppies to initiate a friendly and informal conversation with the child. Children’s recycling function correctness was explored through a play-based approach, where the children were asked if they would like to teach a teddy bear (named Kim) how to perform recycling activities. They were given three items – a banana peel, a cola can and a plastic bottle – to recycle in various types of trash bins, which included composting, disposal of waste, and PET bottles recycling. Each of the trash bins was marked with illustrations. The interviewer brought all recycling items for a purposeful play-based recycling activity with children. All conversations between the interviewer and the child started with an informal talk about, for example, what the child saw in the illustration and then the interview questions were sometimes repeated or asked in different ways.

Survey questionnaires for guardians and teachers
The questionnaire for guardians consisted of three parts: demography, environment-related practice, and sustainability-related discussions between guardians and children. This paper considered the demographic variable sex. The questions about practices related to car ownership (0 = no, 1 = yes), frequency of traveling with public transport, frequency of sorting garbage at home, and frequency of children participating in sorting garbage at home, the number of garbage types sorted at home (up to 9 different items), and the frequency of visiting recycling stations with children. The questions about frequencies of discussions between guardians and children on four sustainability themes are presented in Figure 2. For all frequency questions, a five-point Likert scale was used with the response options 0 = never, 1 = sometimes a year, 2 = sometimes a month, 3 = sometimes a week, and 4 = every day.

The questionnaires for teachers consisted of four parts: demography, sustainability-related values, environment-related practice, and sustainability-related discussions between teachers and children. In this paper the demographic variables sex, position (teacher and child attendant), and training on EfS (0 = no, 1 = yes) are considered. The value question concerned the importance teachers assign to EfS at preschool on a Likert scale ranging from 1 = not at all important to 4 = very important. The practice-related questions concerned the frequency of sorting garbage at preschool, trash bins availability (0 = no, 1 = yes) and frequency of children participating in garbage sorting, the type of garbage and total number of types sorted at preschool (up to 9 different items), and the frequency of visiting recycling stations with children. The questions about frequencies of discussions between teachers and children on four sustainability themes
1. Before starting the play-based recycling activity, the child was given three trash bins: one with an illustration (eaten apple) for compost, one with an illustration of deposit cans, and one with an illustration of fire in the middle of a triangle for combustible waste. Children were asked if they knew the meaning of the illustrations.

2. Paper, cardboard, newspaper, books, pens, toys, lamps, batteries, metal, food, plastic bags, bottles, cans, clothes.

Figure 2. Excerpt from the instruments for children, guardians and teachers.
are presented in Figure 2. For all frequency questions, a five-point Likert scale was used with the response options 0 = never, 1 = sometimes a year, 2 = sometimes a month, 3 = sometimes a week, and 4 = every day.

Semi-structured interview questions for directors
Directors were interviewed with closed- and open-ended questions. The questions consisted of demographics, sustainability-related values and priority. The demographic variables considered the director’s sex, number of qualified teachers, number of child attendants, number of children, eco-certification (0 = no, 1 = yes), type of eco-certification (Green Flag and Preschool for Sustainable Development). The value and priority questions concerned the importance of EfS at preschool on a Likert scale ranging from 1 = not at all important to 4 = very important.

Pre-testing
The instrument was pre-tested with eight children, aged five to six years, at a non-eco-certified preschool, which was not included in the later study. The preliminary aim was to check the question design, question wording, appropriateness of illustrations, interview techniques and duration. The secondary aim was to collect information on open-ended questions with a view to changing some of them into multiple-choice questions. The pre-test results showed that the term “environment (miljö)” was not known to most of the preschool children; rather, they used the word “nature (natur)”. The children were also more acquainted with the word “day-care center (dagis)” than “preschool (förskola)”. All these findings were considered in the final version of the interview questions. The use of illustrations and a sitting mat with pictures of puppies was found to be helpful in creating a friendly atmosphere during the interviews.

The questionnaire for the guardians was pre-tested on four guardians to identify deficiencies in question design. The questionnaire for teachers was developed based on the findings of interviews with three teachers about their work with EfS at the same preschool. The preliminary questionnaire was pre-tested on seven additional teachers, which resulted in some changes in wording and format. Face validity of the instruments was assessed by the authors and one external researcher.

Data analysis
This section provides a brief description of how qualitative and quantitative data were analyzed.

Qualitative data analysis
A content analysis of children’s responses to the open-ended questions was conducted to describe the patterns and trends in communicative content (Weber, 1990). Qualitative data were read and reread as a means of familiarization, and notes were kept of interesting patterns, inconsistencies and contradictions within and between individuals and groups (Hammersley & Atkinson, 1983). To systematically categorize, classify and analyze qualitative data, the five levels of Biggs and Collis’ (1982) Structure of the Observed Learning Outcomes (SOLO) Taxonomy were operationalized and applied as an analytical tool. The levels include the prestructural level (a student misses
the point), the unistructural level (a student has an idea or carries out a task, which can be relevant but inconsistent with each other), the multistructural level (a student has several ideas, but the relationship between them is missing), the relational level (a student links or connects the ideas), and the extended abstract level (a student has extended ideas and can generalize or create a new understanding). The SOLO Taxonomy has been used to measure cognitive learning outcomes and understanding in various subject areas among elementary and high-school students (Biggs & Collis, 1982; Winberg & Berg, 2007). The first two levels (unistructural and multistructural) are more quantitative phases that are related to surface learning outcomes, but the last two levels (relational and extended abstract) are qualitative phases, indicating the deep learning outcomes of the themes (Biggs & Tang, 2011; Hattie & Yates, 2014).

For young learners, the five levels of the SOLO Taxonomy have been adopted with “no relevant idea (prestructural = 0)”, “one relevant idea (unistructural = 1)”, “many relevant ideas, but no link (multistructural = 2), “linked ideas (relational = 3)” and “extended ideas (extended abstract = 4)” (Hook, Wall, & Manger, 2015). The operationalization of the SOLO Taxonomy for this study is shown in Table 2.

The SOLO Taxonomy classifies ‘learning outcomes in terms of their complexity, enabling us to assess students’ work in terms of its quality not of how many bits of this and of that they got right’ (Biggs, 2016). The SOLO Taxonomy was developed in line with ‘constructive alignment’. ‘Constructive’ comes from constructivist theory where learners are seen to be constructors of their own knowledge, while ‘alignment’ is rooted in a principle of curriculum theory, which emphasizes how assessment tasks are to be aligned with what is intended to be learned (Biggs & Tang, 2011).

Quantitative data analysis

Overall procedure. Multivariate analyses were performed in SIMCA P + 14 (Umetrics, 2015). In step one, questionnaire and interview data were subject to Orthogonal Partial Least Squares analysis (OPLS) (Trygg & Wold, 2002) to investigate the relationship of children’s functional and declarative knowledge, respectively, with home- and preschool-related practices and factors. In step two, Orthogonal Partial Least Squares Discriminant Analysis (OPLS-DA) (Bylesjö et al., 2006) was used to investigate any differences between eco- and non-eco-certified preschools with respect to the preschool-related practices and factors that were used in step one for predicting children’s understanding. OPLS-DA is specifically designed to identify discriminating variables in two-class models containing large amounts of orthogonal variation in the predictor variables (i.e., variation not relevant for predicting class membership of observations) that otherwise could obscure interpretation of results.

Pre-treatment of data. For some data, ‘composite scores’ were calculated to facilitate interpretation and/or increase validity of the measures. For each teacher, the answers to the two questions about the presence and availability of trash bins for the children at the preschool were summarized, yielding a ‘composite trash bin availability score’ ranging from 0 through 2 (trash bins present and highly available).
Table 2. Operationalization of the SOLO Taxonomy.

<table>
<thead>
<tr>
<th>SOLO level</th>
<th>Prestructural=0</th>
<th>Unistructural=1</th>
<th>Multistructural=2</th>
<th>Relational=3</th>
<th>Extended abstract=4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport use (Declarative knowledge)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I don’t know.</td>
<td>Driving a car is bad for the environment.</td>
<td>Driving a car is bad for the environment. Harmful gas comes from the car.</td>
<td>Driving a car is bad for the environment. (Because) The air gets polluted by the harmful gas from the car.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recycling correctness (Functional and declarative knowledge)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child cannot do it. Or, Child doesn’t know how to recycle various items.</td>
<td>Child can recycle one item correctly, and has one idea.</td>
<td>Child can recycle two or more items correctly, and has some ideas, but does not have linked ideas.</td>
<td>Child can recycle all three items correctly, and can explain why to recycle or what happens to the items after being recycled (cause and effect).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I need help.</td>
<td>We should throw banana peel into the compost.</td>
<td>We should throw banana peel into the compost and the cola can into the recycle bin.</td>
<td>We should put banana peel into the compost bin, because it will become soil and we can plant trees with it.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Extended ideas:
Driving a car is bad for the environment. If you drive a lot, there will be too much pollution in the air, and people and animals will suffocate. If we walk to preschool instead, we will not pollute the air, and walking is good for our health.

Child can recycle all items correctly, and is able to explain why to recycle and what happens to the items after being recycled with extended ideas (double-because).

We should put banana peel into the compost bin, because it will become soil and we can plant trees with it. You can recycle the cola can and get money. Then you can buy ice cream with it. It will be a new cola can again.
Children’s functional knowledge was represented by their recycling function correctness, scored on a scale ranging from 0 (all incorrect) to 3 (all items correctly sorted). Children’s declarative knowledge was based on their SOLO levels in the areas of financial affordability, resource sharing, recycling and transport use. To increase the reliability of the estimation of children’s declarative knowledge, their SOLO levels on the four sustainability aspects were merged into a single score by Principal Component Analysis (PCA), expressing an ‘overall’ declarative understanding of sustainability issues. This PCA-score was used as the measure of children’s understanding in the OPLS analyses.

Recycling activity at the preschools was represented by the types of waste (nine different options were given) and the total number of types of waste that were sorted at the preschool. The responses of teachers to these items were subjected to PCA to generate a single score, summarizing the perceived recycling activity at their preschool for each staff member. For each preschool this score was averaged, generating the “Preschool’s recycling, diversity and number of items” score used in subsequent analyses. The same procedure was applied to describe the frequency by which twelve different areas of sustainability issues were discussed with the children at the respective preschool. This score was labelled “Teachers’ frequency of sustainability discussions with children.” An identical procedure was used for describing the character of the mother’s and father’s frequency of sustainability discussions with their child, and their recycling activity at home. For these measures, no averages were calculated, but the father’s and mother’s scores were used separately. The labels are as follows: “Mother’s [/Father’s] frequency of sustainability discussions with child” and “Mother’s [/Father’s] recycling, diversity and number of items”. All data were scaled to unit variance to avoid any variables ‘dominating’ others solely due to the magnitude of the scale they were measured on.

Relative variable importance. To discern the relative importance of the variables for explaining children’s functional and declarative knowledge, and the differences between eco- and non-eco-certified preschools, the Variable Influence on Projection values (VIP) of the prediction variables were calculated. Although there is no consensus on how to best compare the relative importance of prediction variables when multicollinearity is present, as is the case here, their loadings on latent predictive factors have been argued to provide good estimates (Johnson, 2000). VIP values are such estimates that have been shown to perform well for many types of data sets (Chong & Jun, 2005; Galindo-Prieto, Eriksson, & Trygg, 2015). Variables with VIP values larger than 1 are generally considered to be important for explanatory/predictive ability of the model, while variables with VIPs 1-0.5 are of intermediate importance, and unimportant if below 0.5.

Model validation. For all models, cross-validation (Eastment & Krzanowski, 1982) and cross-validation ANOVA (Ståhle & Wold, 1990) were used for estimating the predictive power of the model for new data. Furthermore, Distance to Model (DModX) analysis and Observation Risk (Orisk) Analysis were performed to assess any undue leverage of single observations. While the first measure gives information on whether an observation (i.e., child) should be regarded as an outlier or not, the latter is an estimate of the
effect of a single observation on the models’ predictions (i.e., the residuals of the model when the observation is part of the model, compared with when it is not).

The critical value of DmodX is calculated from the F-distribution. An observation was considered an outlier if the DmodX value was more than twice as large as the critical value. Observation risk is computed from the difference in residual standard deviation of the predicted variable when the observation is part of the model and when it is not. An observation risk of 1 or lower means that there is no difference in residuals. Observations with an observation risk exceeding 1.5 were excluded, and new models were computed and compared with the original model, with respect to loading patterns and descriptive ($R^2$) and predictive ($Q^2$) ability.

**Results**

In each of the the models explaining children’s declarative and functional knowledge (Tables 3 and 4 respectively), one observation was found with Orisk exceeding 1.5. When deleted, no significant changes in relative VIP could be noticed in any of the models. In no case did DmodX values exceed critical levels. Hence, it was concluded that the models fitted the data well and reflected general patterns, i.e., they were not influenced by a few observations showing large-scale deviations from average responses. As can be seen in Table 5, the cross-validation values were low (though statistically significant according to SIMCA default levels) for the models predicting children’s functional and declarative knowledge, respectively. For these models, cross-validation ANOVA also indicated that their ability to predict new data was low (i.e., low generalizability). Deviations from normal distribution were shown for 13 out of 22 of the independent variables, possibly hampering efficient modelling of the variation in some

<table>
<thead>
<tr>
<th>Variable</th>
<th>VIP</th>
<th>Valence of relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teachers’ perceived importance of EFS at preschool</td>
<td>2.11</td>
<td>Positive</td>
</tr>
<tr>
<td>Level of priority of EFS at preschool</td>
<td>2.09</td>
<td>Positive</td>
</tr>
<tr>
<td>Teachers’ frequency of sustainability discussions with children</td>
<td>1.69</td>
<td>Positive</td>
</tr>
<tr>
<td>Composite trash bin availability</td>
<td>1.65</td>
<td>Positive</td>
</tr>
<tr>
<td>Teachers’ frequency of recycling station visits with children</td>
<td>1.09</td>
<td>Positive</td>
</tr>
<tr>
<td>Preschool’s recycling, diversity and number of items</td>
<td>1.00</td>
<td>Positive</td>
</tr>
<tr>
<td>Mother’s frequency of sustainability discussions with child</td>
<td>0.99</td>
<td>Positive</td>
</tr>
<tr>
<td>Proportion of teachers with training in EFS</td>
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<td>Positive</td>
</tr>
<tr>
<td>Mother reported frequency of child’s participation in recycling</td>
<td>0.91</td>
<td>Positive</td>
</tr>
<tr>
<td>Father’s frequency of sustainability discussions with child</td>
<td>0.87</td>
<td>Positive</td>
</tr>
<tr>
<td>Household owns car</td>
<td>0.87</td>
<td>Negative</td>
</tr>
<tr>
<td>Mother’s public transport use frequency</td>
<td>0.69</td>
<td>Positive</td>
</tr>
<tr>
<td>Father’s frequency of recycling station visits with child</td>
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<td>Positive</td>
</tr>
<tr>
<td>Mother’s frequency of recycling station visits with child</td>
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<td>Positive</td>
</tr>
<tr>
<td>Teachers’ frequency of recycling activity with children</td>
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</tr>
<tr>
<td>Father reported frequency of child’s participation in recycling</td>
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<td>Positive</td>
</tr>
<tr>
<td>Father’s recycling, diversity and number of items</td>
<td>0.23</td>
<td>Positive</td>
</tr>
<tr>
<td>Mother’s recycling, diversity and number of items</td>
<td>0.19</td>
<td>Positive</td>
</tr>
<tr>
<td>Father’s recycling frequency at home</td>
<td>0.13</td>
<td>Negative</td>
</tr>
<tr>
<td>Father’s public transport use frequency</td>
<td>0.09</td>
<td>Positive</td>
</tr>
<tr>
<td>Mother’s recycling frequency at home</td>
<td>0.08</td>
<td>Negative</td>
</tr>
</tbody>
</table>
variables. Log transformation did not change this, so the untransformed data were used in the analyses. Residuals were normally distributed in all models. Although the low generalizability was not surprising, given the nature of the data and the low number of participants, this means that caution is warranted when interpreting the results.

Table 3 shows that the six variables with the strongest association with children’s declarative knowledge of sustainability issues were preschool-related, and the six variables with the weakest association and the one with negative association were all home-related. Variables considered to be important for the predictive ability of the model and with a positive relation to children’s declarative knowledge of sustainability were Teachers’ perceived importance of EfS, Level of priority of EfS at preschool, Teachers’ frequency of sustainability discussions with children, Composite trash bin availability, Teachers’ frequency of recycling activities with children, and Preschool’s recycling, diversity and number of items. The variable Household owns car had a negative association and was of intermediate importance.

Table 4 indicates that children’s functional knowledge in terms of recycling correctness was positively associated with visiting the recycling station with teachers and the recycling habits (types of waste sorted) of the preschool, whereas children’s functional knowledge in terms of recycling correctness was negatively associated with visiting recycling stations with mother and father, mother’s and father’s recycling frequency at home and teachers’ frequency of sustainability discussions with children.

Table 6 shows that the differences between preschools mainly lie in the availability of trash bins for the children, but also in the perceived importance of EfS issues by teachers and management and the frequency of recycling station visits and sustainability discussions with the children. For all these variables, eco-certified preschools showed higher levels/frequencies than non-certified preschools. Apparently, the extent of EfS training among the staff and the frequency and scope of recycling
activities (the latter actually being slightly higher in non-certified preschools) with the children do not differ so much between eco-certified and non-eco-certified preschools.

Table 5 shows that although moderate amounts of the variation in children’s declarative and functional knowledge are described by the models, the cross-validation indicates that the models are non-significant. The $R^2$, DModx and Orisk analyses indicated that the models fit the data. However, $Q^2$ values (Table 5), permutation testing (not shown) and cross validation ANOVA show that the generalizability of the relationships between children’s knowledge and home and preschool factors are low for both outcomes ($F(4, 48) = 0, p = 1$ for recycling function correctness and $F(2, 50) = 0, p = 1$ for understanding). In contrast, there is a significant relationship between eco-certification and the preschool practices (Table 5) in terms of the eight measured characteristics (Table 6). This relationship is well-modelled ($R^2Y = 0.86$), and the model also fits ‘new’ data well ($Q^2 = 0.80$). Cross validation ANOVA supports the validity of the model ($F(6, 46) = 31.27, p < .001$) as does the response permutation test (graphical output, not shown). Trash bin availability, the priority of EfS at the preschool (according to both directors and teachers), and discussions of sustainability-related issues are the most important variables in the model, and are higher/more abundant at eco-certified than non-eco-certified preschools.

A two-tailed t-test showed that there was no significant difference in children’s declarative knowledge between eco- and non-eco-certified preschools ($t (2, 51) = -1.792, p = .079$). Neither was there any significant difference in children’s functional

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>A</th>
<th>N</th>
<th>$R^2_X$</th>
<th>$R^2_{X*}$</th>
<th>$R^2_Y$</th>
<th>$Q^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declarative knowledge</td>
<td>1+0+0</td>
<td>53</td>
<td>0.16</td>
<td>0.16</td>
<td>0.19</td>
<td>-0.10</td>
</tr>
<tr>
<td>Functional knowledge</td>
<td>1+1+0</td>
<td>53</td>
<td>0.26</td>
<td>0.10</td>
<td>0.29</td>
<td>-0.10</td>
</tr>
<tr>
<td>Eco versus non-eco-certification</td>
<td>1+2+0</td>
<td>53</td>
<td>0.66</td>
<td>0.32</td>
<td>0.86</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Note: A is the number of components in the model; the first figure in this column indicates the number of predictive components – i.e., capturing joint variation between independent and dependent variables (X and Y); the second figure indicates the number of components in the X data that were not associated with Y; and the third figure indicates the number of components in Y that were not associated with X. N is the number of students who responded to the items in each model. $R^2_X$ is the percentage of variation in the independent variables that is described by each model ($R^2_{X*}$ denotes how much of this variation pertains to the dependent variable). $R^2_Y$ and $Q^2$ are the percentages of variation in the dependent variable that is described and predicted, in that order, by the model.

Table 6. VIP values of preschool associated variables statistically predicting eco-certification of the preschool. A positive valence means the variable is associated with eco-certification (as opposed to non-eco certification).

<table>
<thead>
<tr>
<th>Variable</th>
<th>VIP</th>
<th>Valence of relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite trash bin availability</td>
<td>1.51</td>
<td>Positive</td>
</tr>
<tr>
<td>Level of priority of EfS at preschool</td>
<td>1.26</td>
<td>Positive</td>
</tr>
<tr>
<td>Teachers’ perceived importance of EfS at preschool</td>
<td>1.16</td>
<td>Positive</td>
</tr>
<tr>
<td>Teachers’ frequency of recycling station visits with children</td>
<td>1.14</td>
<td>Positive</td>
</tr>
<tr>
<td>Teachers’ frequency of sustainability discussions with children</td>
<td>1.12</td>
<td>Positive</td>
</tr>
<tr>
<td>Proportion of teachers with training in EfS</td>
<td>0.35</td>
<td>Positive</td>
</tr>
<tr>
<td>Teachers’ frequency of recycling activities with children</td>
<td>0.26</td>
<td>Positive</td>
</tr>
<tr>
<td>Preschools’ recycling, diversity and number of items</td>
<td>0.18</td>
<td>Negative</td>
</tr>
</tbody>
</table>
knowledge according to a Mann-Whitney U test (U = 344, p = .172). Hence, there are reasons to believe that the differences found between eco-certified and non-eco-certified preschools, in terms of the investigated variables, are not crucial for children’s functional and declarative knowledge.

**Discussion**

This study shows a positive association between, on the one hand, children’s declarative knowledge of sustainability issues and, on the other hand, teachers’ views of EfS, the priority of EfS in educational work at preschool, and children’s participation in discussion and engagement in recycling activities with teachers. However, children’s functional recycling knowledge was found to be negatively associated with discussions with teachers on sustainability issues, but positively associated with the frequency of children’s recycling station visits together with teachers, and the scope and magnitude of recycling at the preschool. In contrast, verbal interaction with children about EfS issues and the perceived high value of those issues among teachers and management seems to be more beneficial for children’s declarative knowledge than the functional knowledge of EfS, although these are also positively correlated with children’s declarative knowledge. Together, these findings support the argument that preschool and teachers may play an important role in developing children’s declarative and functional knowledge through children’s participation in discussion and involvement in sustainability-related issues. These findings are in line with previous environmental and sustainability-related studies, which demonstrated that children, with support and guidance from their teachers, learned about different local and global issues through their participation in the conversations and through being engaged in activities related to sustainability (Davis 2005; Lewis, Mansfield, & Baudains, 2010; Mackey, 2012).

The results of our study also indicate that the mothers’ and fathers’ discussions and activities are differently associated, in terms of magnitude, with children’s declarative and functional knowledge. This resembles findings reported by Sigel et al. (1991), who found that mothers’ and fathers’ beliefs and behaviors had different effects on their children’s beliefs and behaviors. Interestingly, the study showed that the more the mothers and fathers recycled at home, assumingly without involving children, the less practical knowledge regarding recycling the children had. A similar relationship could be seen for recycling at the preschool and, somewhat surprisingly, for the frequency of recycling activities together with children at the preschool. Although it could be argued that the children would have learned from the adults by viewing them sorting the waste (Bandura, 1977), an alternative explanation could be that the more extensive the recycling, the less time the adults may feel they have for involving the children, who might then focus on other activities than watching the adults. In consistent with other studies, this finding emphasizes the importance of involving children in discussions and activities related to sustainability issues, both at home and at preschool (Davis, 2005; Mackey, 2012). From this perspective, the negative correlation found between children’s recycling function correctness and the stated frequency of recycling activities with children at the preschool is surprising. A possible explanation could be that this question asked for the frequency of recycling activities with the children, and not what kinds of activities and to what extent the children were actively involved in
them. Thus, recycling activities with children at preschool might not have involved the children to any higher extent, e.g., sorting waste while the children watched might have been classified by the teachers as “...together with children”. This could explain the similarities in VIP values between this variable and “Father’s /Mother’s recycling frequency at home” in the models predicting children’s functional and declarative knowledge respectively.

The study did not show any statistically significant differences in children’s declarative and functional knowledge between eco- and non-eco-certified preschools. This finding is in line with the findings of a previous study that explored perceptions of the learning experiences related to EFS among 10- to 12-year-old children (Manni, Ottander, Sporre, & Parchmann, 2013). Results of a nationwide study that measured sustainability consciousness in compulsory schools showed a positive but small association with eco-certified schools among students in grade six, while the association was negative among students in grade nine (Olsson, Gericke, & Chang Rundgren, 2015).

Many children under six years of age could justify their ideas and thoughts, but their level of justification varied regardless of the type of preschool they attend. The complexity of the justifications among the children at eco-certified preschools tended to be higher compared with those a non-eco-certified preschools. These findings are consistent with the research of Davison et al. (2003) on children’s attitudes towards sustainable transport in Scotland. They reported that children who participated in whole-school programs, such as eco-schools or schools that promote a healthy lifestyle, had a deeper understanding of these issues.

In this study the children from eco-certified preschools were over-represented: 35% of the guardians of children at eco-certified preschools consented to their children’s participation, while 20% of the guardians of children at non-eco-certified preschools consented. The reason for this is not known. It could be related to the guardians’ motivation and commitment to sustainable development issues, but it could also be that the information about the study was not passed on by teachers to all guardians. During the data-collection process, it was found that information letters given to one of the non-eco-certified preschools were not delivered to any guardians in due time, which resulted in less participation on the part of the children and their guardians from that preschool. Despite the weakness of the sample, in terms of its size and representativeness, the strengths of this study are that the preschools were purposefully selected and the interview instruments were thematically connected in order to analyze the correlation of factors related to children, their guardians, teachers and directors. The purposeful selection of preschools helped to include equal numbers of eco-certified and non-eco-certified preschools in the study, despite eco-certified preschools not being situated in all municipalities in Sweden. Through the sampling process, it was possible to acquire necessary data, which allowed for investigating if eco-certification was associated with any beneficial preschool educational practices. The quantitative data provided a more general picture of children’s declarative and functional knowledge, whereas the qualitative data offered a deeper understanding of the phenomena of children’s ideas and thoughts on four themes (Creswell & Clark, 2011).

The adaptation of the SOLO Taxonomy for young children was found to be useful for systematically assessing and classifying children’s open-ended responses concerning financial affordability, resource sharing, recycling and transport use.
Conclusion and implications for research

Considering the limitations of this study, there must be caution when the findings are interpreted and generalized. However, the findings demonstrate a significant and positive relationship between young children’s learning about sustainability and the involvement of teachers and guardians in sustainability-related discussions and activities. It is important to ensure that children are given the opportunity to participate in discussions and practical activities, both at home and at preschool, that concern their lives, because they are capable of engaging in issues related to economic, social and environmental dimensions of sustainability. A nationally representative survey of sufficient statistical power would be required to explore whether eco-certification of preschools has a role to play in developing children’s understanding and practices of sustainability-related issues, especially in a country where the preschool curriculum already addresses environmental and sustainability issues. Such evidence is needed for practitioners and policymakers to improve educational practices and facilitate policymaking. This is particularly relevant to the Education 2030 Framework for Action and its target for ensuring “that all learners acquire knowledge and skills needed to promote sustainable development.” (UNESCO, 2015, p. 8). Therefore, further studies are needed to investigate the extent to which different educational activities contribute to developing children’s understanding and behavior towards a sustainable society.

Acknowledgements

The authors would like to thank all participating children, guardians, teachers and directors. They would also like to thank Prof. John Biggs and Pam Hook, Educational Consultant and Researcher, HookED, for their generous support concerning the SOLO Taxonomy. The authors gratefully acknowledge the support of Dr. Johan Borg, Lund University, the editor and the reviewers for their valuable comments to improve the quality of this paper. Interview illustrations were made by Pauline Borg.

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Mikael Winberg currently coordinates a longitudinal international research project on how students’ motivation and epistemic beliefs develop over grade 5 - 11, how the characteristics of teaching contributes to this development, and how students’ motivation and epistemic beliefs affect students’ chemistry knowledge development. Mikael earned his PhD in 1996 in chemistry education research and has since this been interested in how students’ motivation and epistemic beliefs influence various aspects of their learning process and outcomes.

Monika Vinterek is Professor of Educational Work at Dalarna University and Director of Education and Learning which is a research environment of about 50 researchers and more than 20 PhD students in educational science. Her main research interests are general questions of teaching and learning and especially what it takes to stimulate children and students to develop knowledge, in which different kinds of skills are included.
References


