Working with Statistics in Kindergarten
A Sustainable Approach

Stein Berggren[1], Paal Jom[2,]

Østfold University College, Norway[1]
Nord University, Norway[2]

Abstract

This study explores the integration of sustainability and statistical thinking ([1]) in a kindergarten setting. Conducted in collaboration with a health-promoting kindergarten ([2]), the research aims to address the UN's Sustainable Development Goal 3: Good Health and Well-being ([3]). The study involved 18 four-year-old children who engaged in activities that combined learning about healthy eating and statistical concepts. Using a playful approach ([4]; [5]), children created bar charts with blocks to visualize their favorite lunch foods, followed by discussions to interpret the bar charts. Observations were made during these activities to gather data on the children's engagement and understanding. The data was analyzed using a thematic qualitative analysis strategy ([6]), focusing on the children's use of statistical thinking and mathematical concepts. The findings suggest that early education on sustainability and health, supported by statistical thinking, can foster long-term positive habits and awareness among young children.

Keywords: *Sustainability. Kindergarten Education, Statistical Thinking, Healthy Eating, UN Sustainable Development Goals*

1. Introduction

This study explores sustainability as its central theme through a collaboration with a kindergarten. Grounded in the Framework Plan for Kindergartens ([7]), the study emphasizes that sustainable development encompasses nature, economy, and social conditions. To preserve life on Earth for future generations, children need to learn to care for themselves, others, and the environment. Kindergartens thus serve as vital spaces for nurturing values, attitudes, and practices that foster a more sustainable society, encapsulated in the statement: "The kindergarten shall help children to understand that today's actions have consequences for the future" ([7]).

Sustainable development affects everyone throughout different phases of life ([8]; [9]). Although many of climate change results from human actions ([8]; [9]), individuals may feel their efforts are insignificant. In this context, statistics can illustrate the importance of individual contributions within the larger picture. By employing statistical data, we can visualize potential changes resulting from collective actions, whether by everyone or half the population. This approach sheds light on how both small and substantial contributions impact the broader landscape, potentially motivating enduring changes and inspiring local communities toward sustainable practices.

We each have the potential to contribute to sustainable development ([8]; [9]). However, altering habits requires time, making kindergartens ideal starting points for embedding sustainability-focused practices early on. One approach is adjusting dietary habits to increase awareness of food consumption; for instance, reducing meat intake can positively affect the environment ([10]). The kindergarten involved in our study is a health-promoting institution, adhering to criteria from the "Eighteen Thousand Hours" project ([2]). Two pertinent criteria include following national dietary and nutrition guidelines and integrating health-promoting initiatives into their management documents, quality systems, and daily operations ([2]).

In the kindergarten, statistical work is integrated within the domain of numbers, spaces, and shapes outlined in the Framework Plan for Kindergartens ([7]). This domain encourages children to engage in playful and exploratory activities like comparison, placement, visualization, and counting ([7]). Together with the kindergarten, we devised and executed a project focusing on sustainability and statistics. Two educators facilitated the activity involving 18 four-year-olds. Using the food the children ate for lunch, they created a bar chart with blocks to represent their food preferences. The subsequent mathematical dialogue helped them interpret the bar chart through comparison, numbers, and

counting. Collaboratively, the project was tested, evaluated, and refined to ensure the kindergarten's ownership and future implementation independence.

This study aims to address the research question:

> **How can the United Nations Sustainable Development Goal "Good Health and Well-being" be integrated as an approach to working with statistics in kindergartens?**

The UN Sustainable Development Goals target the root causes of poverty, inequality, and climate change, with Goal No. 3 - Good Health and Well-being - aiming to ensure healthy lives and promote well-being across all ages ([3]). A crucial aspect of achieving good health and well-being is related to dietary choices.

We will now outline the theoretical framework pertinent to our research question, followed by an explanation of how observations were used to collect data. We'll then detail our data analysis process, discuss ethical considerations, and present results aligned with our research question. Finally, we'll summarize our findings and their relation to sustainability, mathematics, and statistics.

2. Theory

In this section, we present the theory that are relevant to the research question on the study. We begin by examining the learning environment and facilitation, focusing on inquiry landscapes and the significance of dialogic interactions. Next, we discuss the role of play in play-based learning and how concrete materials can enhance learning experiences. Lastly, we introduce a framework for understanding statistical thinking.

The Framework Plan for Kindergartens ([7]) guides children's activities in kindergarten, advocating a learning environment where everyday experiences and surroundings become foundations for learning. This approach situates reality as the backdrop for children's curiosity and exploration. Consequently, multiple answers may emerge from each question, and inquiries can take many different directions to the question. Such a learning environment, fostering curiosity and enabling children to shape the learning journey, is termed an "inquiry landscape" by Alrø and Skovsmose (2002) ([11]).

An inquiry landscape encourages risk-taking with open-ended processes and steers away from questions seeking definite answers. Wells (1999) emphasizes that in an inquiry-driven learning environment, children ask questions, express wonder, and seek knowledge collaboratively ([4]). Learning in kindergartens often unfolds through conversations. For these discussions to enrich the learning environment, staff must adopt a curious, questioning, and critical stance ([12]), and structure activities and communication in such a way that that the children can get a deep insight into the activities ([13]).

Throughout activities, spontaneous conversations may arise, but staff are tasked with guiding children back to the subject matter. It is their responsibility to unite children around a shared academic theme, possibly using images or concrete materials ([14]). This orchestration provides context for activities and introduces mathematical concepts. Carlsen (2013) illustrates how a kindergarten teacher orchestrated a mathematical activity based on a fairy tale, framing it as a sociocultural engagement. This involves linguistic interactions with mathematical ideas, engaging both staff and children. Carlsen's study ([4]) shows strategic questioning encouraging reflection and reasoning, linking past experiences to new learning.

Play is an important element in kindergarten. Björklund et al. (2018) propose four strategies that staff can use to facilitate play-based, targeted math teaching: affirming interest, introducing new strategies, situating familiar concepts, and offering new perspectives ([15]). By employing various strategies, staff offer multiple avenues for children to tackle mathematical questions. Diverse strategies challenge the conceptual understanding of mathematical ideas in different ways, potentially broadening children's comprehension.

Physical objects used to support the development of children's mathematical skills are known as manipulatives. Despite varying definitions, Sarama and Clements (2009) suggest manipulatives are typically regarded as tangible objects children can touch and explore ([16]). Laski et al. (2015) identify four principles to effectively use manipulatives in math education: (1) use the same materials over extended periods, (2) begin with simple manipulatives, gradually introducing abstract forms, (3) avoid objects resembling everyday items, and (4) clarify the link between manipulatives and math content ([17]). Implementing these principles may enhance teaching effectiveness, bolstering children's problem-solving and critical thinking, thereby improving math outcomes ([17]).

Jones et al. (2000) formulated a framework characterizing children's statistical thinking ([1]), drawing on Biggs and Collins' cognitive development model (1991) ([18]). Although designed for primary school students in grades 1-5, this framework is applicable to kindergarten children. The statistical thinking targeted in first-grade curriculums is also explored by older kindergarteners. The framework consists of four categories: (1) describing data, (2) organizing and reducing data, (3) representing data, and (4) analyzing and interpreting data. Describing data involves examining provided data, such as assessing if different representations convey identical information. Organizing and reducing data entails cognitive tasks like grouping and summarizing data. For four-year-olds, the first two categories may pose challenges due to conceptual limitations in categorizing data, making the last two categories more relevant for their statistical work. Representing data involves crafting diverse visual representations, while interpreting data encompasses identifying patterns, comparing quantities, employing mathematical concepts, and drawing conclusions.

3. Methodology

In this section, we outline the activities conducted with the children and describe how the observations were carried out.

3.1. The Activities With the Children

Collaborating with kindergarten staff, we devised a project where children engaged with themes of sustainable development and statistics. The activity comprised two parts. The first part served as an introduction, immersing the children in discussions about healthy food. In the second part, the children constructed a bar chart using blocks to visualize their preferred lunch choices. This activity was followed by a mathematical discussion. Observations from the second part form the data foundation for our study.

Initially, a kindergarten staff member read a book about baking, followed by a discussion on the topic. The children then drew cakes, leading to discussions about healthy food and the notion that they can't eat cake every day. The conversation expanded to cover familiar healthy foods and typical kindergarten lunches.

Following this, the children drew their favorite lunch, which encouraged them to reflect on their dietary experiences, aligning with the UN's Sustainable Development Goal of Good Health and Well-being. Subsequently, the children used blocks to create a bar chart, illustrating the popularity of various dishes. A staff member then led a discussion about bar chart on the picture of each dish, comparing quantities and totals of blocks.

There were four pictures of four different dishes: pasta with meat sauce, salmon with potatoes, spinach soup, and one unhealthy option. The spinach soup was cleverly dubbed "Hulk's Soup," emphasizing growth and strength - capitalizing on the children's familiarity with the fictional character. The children made bar charts on the pictures of the dishes, based on which dishes they liked.

The blocks for the bar charts were in a variety of colors (red, white, and black), intended to enhance practice with mathematical concepts. After the children had discussed which dishes they liked best, they counted and discussed how many blocks of different colors there were on the different dishes and how many blocks in total.

This activity was conducted with four-year-olds participating in action research, consisting of 18 children divided into three smaller groups of six. Kindergarten staff organized these groups. The collaboratively designed project was executed at different times for each group, with adjustments made between sessions based on observations. Notably, the unhealthy category received more attention, prompting a switch from chocolate cake to buns to remind children of the earlier conversation about healthy eating. A change in staff leadership on the third occasion ensured greater staff engagement and experience with the project, aiding its future independent implementation.

3.2. Observation

Our observations aimed to address the research question and led to adjustments during the study (changing images and rotating staff members). While we observed the entire activity, observations from the second part, concerning lunch and the bar charts, most effectively answered the research question.

We prepared an observation sheet with two columns: one for observations and another for reflections. Each team member noted observations independently, documenting children’s drawings,

conversations, discussions about food, interactions over the stacked diagram, and collaborative efforts in creating it. We also recorded personal reflections during this process. After individual reviews, we refined observations for the best data foundation to address the research question, repeating this process for all groups. We synthesized observations into six documents, two per group, with each observation lasting about an hour, including 20 minutes focused on the bar charts activities. Overall, we compiled 18 pages of observations, with eight pages detailing the bar charts work.

Before our visits, a staff member briefed the children about our presence, facilitating our role as complete observers ([19]). Thus, we observed quietly, monitoring all activities. As noted by Postholm and Jacobsen (2022), the spatial dimension in observation pertains to location and subjects. Our observations took place in the children's familiar kindergarten environment, focusing on six children interacting with a staff member.

4. Analysis

In our analysis, we concentrated on observations from the project that dealt with the lunch the children had eaten at kindergarten and their engagement with the bar charts.

Our approach was inductive, initially identifying elements related to sustainability, and subsequently pinpointing data relevant to statistics and mathematics. This analysis was guided by a theme-based qualitative strategy ([6]; [21]), which involves identifying codes and categories within observations to uncover patterns in the children's statements and actions (see Table 1). Table 1 outlines the analytical steps that culminated in the identification of two main categories: numerical concepts and statistical thinking.

Steps in the analysis strategy	
Faamiliarize with the data	We summarized observations from each of our observations and transcribed the data material.
Define the scope of the data	Observations and statements related to healthy food and sustainability, examples of statements from children related to the categories in the stacked diagram: "I like salmon," "Fish makes you big and strong," "Then we get big muscles, bigger than the Hulk."
Create initial codes	After identifying healthy food and sustainability, we found codes related to mathematics and statistics for further analysis. Examples of codes: highest, lowest, 1, 2, ..., 10, red, white, black, 7-1-2-2, 4-2-3-3.
Search for categories	After organizing the codes, we identified overarching categories for the codes: Number Counting Relational word (highest/lowest, most/fewest) Sorting/quantities
Define the categories	In this step, we merged the categories into the two main categories: numerical concepts and statistical thinking.

Tabel 1. Steps in the analysis strategy

Children's interactions with each other and the staff member surfaced either through answers to staff questions, conversations among themselves, or echoes of staff remarks. For example, when a child pointed towards the image of salmon and expressed "I like salmon," this was interpreted as the child articulating one of the quantities depicted in the stacked diagram, leading us to annotate the code "salmon" under sorting/quantities. These codes emerged from instances when children described the number of blocks associated with various dish images or referred to specific dishes while pointing to their respective categories in the stacked diagram. The use of relational terms was evidenced when children compared tower heights, saying "it is the tallest" or "there are fewer blocks," thereby engaging in comparative assessments.

4.1 Ethical Perspectives

As researchers, maintaining ethical integrity is crucial throughout data collection and presentation. According to Postholm and Jacobsen (2022), ethical principles should be embedded in the research process and underpin subsequent presentation of the work ([20]). Prior to commencing, we distributed information sheets to parents and staff, explicitly stating that participation was voluntary. Child groups comprised only those whose parents had consented to participation.

Moreover, it's important to recognize how our presence may influence the data we collect. Our method relied on observation, meaning our presence could potentially alter the nature of the data compared to if we had not been present. To minimize influencing the data beyond our mere presence, we ensured the staff member was thoroughly familiar with the program and its intended execution. The staff member had spoken to the children in advance about our arrival and put together groups of children based on their knowledge of the children. At the beginning of the project, we briefly introduced ourselves to the children and then remained as unobtrusive as possible, allowing the activity to proceed without input from us.

Having two observers working independently strengthened the foundation of our analysis, enhancing the reliability of our interpretations and findings. This dual approach contributes to what Postholm and Jacobsen (2022) refer to as validity ([20]).

5. Results And Discussion

We will now illustrate how the children's statements were connected to the bar charts they created. When the children counted and provided numbers, they articulated these using number words; for simplicity, we have represented these as numerical symbols. For example, when the children counted the blocks in a tower in the bar chart, reaching 1-2-3, or when they tallied all the blocks as 1-2-3-...-11-12, we classified this as counting. The concept of number was evident when the children pointed at a tower and said 'two' or when they counted the blocks in a tower and repeated the last number, 1-2-3-4, 'four'. Their ability to count up to twelve demonstrated knowledge of number sequences and mastery of one-to-one correspondence, linking a number word to each block counted. Saying 'two' without counting blocks exemplifies immediate number perception. Understanding of cardinal numbers was shown when children reiterated the final number in their count as the quantity of items in the set.

In Table 2, observation codes are organized under two main categories with corresponding subcategories. The numbers within the sorting/quantities category reflect expressions from the children and the adult summarizing the block counts across various dishes.

Main Categories, Subcategories, and Codes in the analysis			
Numerical Concepts		**Statistical Thinking**	
Number	**Counting**	**Relational word**	**Sorting/quantities**
4 7 3	1,2,3,4....,12 1,2,3,4	highest lowest fewer most equal amount	7-1-2-2 4-2-3-3 Salmon

Table 2. Main Categories, Subcategories, and Codes

The wooden blocks used in constructing the bar charts are referred to as manipulatives ([16]), neutral objects without specific item representation. For instance, using toy cars as manipulatives could detract from focus on the bar chart. During program implementation, the staff member emphasized the relationship between manipulatives and mathematical content, ensuring the blocks represented quantities. This aligns with the final two principles outlined by Laski et al. (2015) for enhancing mathematics learning through manipulatives ([17]).

Our observations indicated that the staff member utilized the third approach described by Björklund et al. (2018), embedding mathematical content in a playful context ([15]). Children are accustomed to building towers during play, and this context was adapted to tower construction representing quantities of different dishes. Familiar play elements were thus integrated into a mathematical context to engage with statistical concepts via block-based stacked diagrams.

Although the staff member guided the activity, they adopted an inquisitive and curious approach ([4]; [12]). The staff member demonstrated this by posing questions such as: "Which picture has the most blocks?" For effective inquiry-based learning, it is crucial for the staff member to direct activities

purposefully ([13]). The staff member's role is to bring children together around a shared scholarly subject ([14]). Using dish images and physical wooden blocks (bar chart), the staff member steered discussions towards numbers and numerical relationships (fewest/most). This created a learning environment where children's questions and curiosity fostered an inquiry landscape ([11]).

The objective of these discussions was to enrich or expand the children's understanding and knowledge of statistics ([14]). Hence, effective communication between the staff member and children was vital. During the third session, this became apparent when a different staff member led the activities. It was clear this staff member felt less confident with the program, impacting their ability to direct and control activities as effectively as in previous sessions.

Working with the bar charts, the children engaged with both statistical elements and numerical concepts in mathematics. Counting and verbalizing number words are fundamental to numerical concepts in mathematics. By physically creating the bar charts, the children explored statistical thinking, particularly within two categories in the framework by Jones et al. (2000) ([1]). They represented data by crafting the bar charts based on favored dishes. Observing the bar charts and counting blocks allowed them to interpret data, discerning which dish was more or less popular (most or fewest liked).

Taking a broader perspective - a mathematical one - reveals that the children explored the mode (the most "typical" observation, represented by the dish with the most blocks). This measure of central tendency is one they will encounter later in school statistics. It is the sole measure applicable here since diagram categories are non-numerical data. Relating this activity to measures of dispersion isn't feasible, as definitions of measures of dispersion rely on numerical data.

Additionally, conversations shifted towards healthy food when buns replaced cake as the unhealthy choice. In the initial session, over half of the blocks favored cake, whereas in subsequent sessions, buns became the preferred choice. Children expressed their preferences by stating dish names along with "I like best" as they placed blocks, and they discussed past experiences of consuming these dishes in kindergarten.

6. Conclusions

The mathematical focus of our study is on statistics, yet interpreting a statistical representation requires contextual placement. In our research, this context was built around sustainability and healthy food. The study begins with the research question: "*How can the UN's Sustainable Development Goal of Good Health and Well-being be utilized as a framework for teaching statistics in kindergarten?*" We addressed this question by illustrating a project suited for kindergarten settings.

Considering the age of the participants, four-year-olds, we employed orchestration ([5]) to establish a foundational framework for linguistic interactions. By having the staff member initiate the session with a reading from a book about baking, we aimed to convey the message that excessive consumption of cake and candy is undesirable. Instead, children should focus on consuming healthy foods daily, recognizing their role in promoting overall health and well-being ([3]). Incorporating familiar dishes within the context of healthy eating proved to be an effective educational tool for engaging the children.

The study's project was crafted by designing a learning environment reflective of the children's everyday experiences and surroundings. This method created a natural setting where children could explore and engage actively in the learning process. By focusing the study on lunches eaten at kindergarten, we crafted a playful yet meaningful mathematics project that integrated mathematics within the context of Good Health and Well-being.

The interactions between children and staff were notably characterized by curiosity and communication. Often, staff members guided discussions to ensure children received answers to questions related to the study's academic theme. The staff orchestrated both conversations and activities, highlighting the importance of their role. When the project was conducted by a different staff member, it noticeably influenced the quality of orchestration.

For future exploration, it would be compelling to examine how this implementation might vary with another group of four-year-olds if the staff member had read a book focused on healthy food instead of baking. Additionally, it would be interesting to assess the impact of using uniformly colored blocks to determine whether the color aspect holds any significance.

REFERENCES

[1] Jones, G., Perry, B., Putt, I. & Nisbet, S., (2000). Assessing and Fostering Children's Statistical Thinking. *ICME 9.* https://www.researchgate.net/publication/245507779_Assessing_and_Fostering_Children's_Statistical_Thinking
[2] Østfoldhelsa. (2015, 13. mars). *Prosjekt atten tusen timer*. https://ostfoldhelsa.no/ukategorisert/prosjekt-atten-tusen-timer/
[3] UN-SDG (2025, 25. Februar). *UN substainable development goals*. https://www.un.org/sustainabledevelopment/
[4] Wells, C.G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory of education.* Cambridge University Press.
[5] Carlsen, M. (2013). Engaging with mathematics in the kindergarten. Orchestrating a fairy tale through questioning and use of tools. *European Early Childhood Education Research Journal, 21*(4), 502–513. https://doi.org/10.1080/1350293X.2013.845439
[6] Widerberg, K. (2001). *Historien om et kvalitativt forskningsprosjekt: en alternativ lærebok* (K. Bolstad, overs.). Universitetsforlaget.
[7] Kunnskapsdepartementet (2017). *Rammeplan for barnehagen: Forskrift om rammeplan for barnehagens innhold og oppgaver*. https://www.udir.no/contentassets/7c4387bb50314f33b828789ed767329e/rammeplan-for-barnehagen—bokmal-pdf.pdf
[8] Greenpeace. (u.å.). *Klimaendringer*. https://www.greenpeace.org/norway/klimaendringer/
[9] WWF. (u.å.). *Klimaendringer*. https://www.wwf.no/klima-og-energi/klimaendringer
[10] Solemdal, L. (2019). *Mat og bærekraft – matproduksjon og kosthold i et bærekraftsperspektiv*. (Norsøk Rapport,Vol. 4, Nr. 11). NORSØK. https://orgprints.org/id/eprint/36468/
[11] Alrø, H. & Skovsmose, O. (2002). *Dialogue and learning in mathematics education: intention, reflection, critique.* Kluwer Academic Publishers.
[12] Erfjord, I., Carlsen, M. & Hundeland, P.S. (2015). Distributed authority and opportunities for children's agency in mathematical activities in kindergarten. *European Society for Research in Mathematics Education*. Conference paper. s 1918 - 1924. https://hal.science/hal-01288470/
[13] Kuhlthau, C., Maniotes, K., & Caspari, A. (2015). *Guided Inquiry: Learning in the 21st entury* (2. utg.). ABC-CLIO.
[14] Gjems, L., Jansen, T. T. & Tholin, K. R. (2012). Fagsamtaler i barnehagen. *Nordisk barnehageforskning*, *5* (22), 1-12. https://nordiskbarnehageforskning.no/index.php/nbf/article/view/32
[15] Björklund, C., Magnusson, M. & Palmér, H. (2018). Teachers' involvement in children's mathematizing – beyond dichotomization between play and teaching. *European Early Childhood Education Research Journal, 26*(4), 469– 480. https://doi.org/10.1080/1350293X.2018.1487162
[16] Sarama, J. & Clements, D. H. (2009). "Concrete" Computer Manipulatives in Mathematics Education. *Child development perspectives, 3*(3), 145-150. https://doi.org/10.1111/j.1750-8606.2009.00095.x
[17] Laski, E. V., Jor'dan, J. R., Daoust, C. & Murray, A. K. (2015). What Makes Mathematics Manipulatives Effective? Lessons From Cognitive Science and Montessori Education. *SAGE open*, *5*(2). https://doi.org/10.1177/2158244015589588
[18] Biggs, J. B., & Collis, K. F. (1991). Multimodal learning and intelligent behavior. I H. Rowe (red.), *Intelligence: Reconceptualization and measurement.* Psychology Press.
[19] Gold, R.L. (1958). Roles in sociological field observation. *Social Forces*, *36*(3), 217-223. https://msessd.ioe.edu.np/wp-content/uploads/2017/04/GOLD-PARTICIPANT-OBSERVATION.pdf
[20] Postholm, M. B. & Jacobsen, D. I. (2022). *Læreren med forskerblikk. Innføring i vitenskapelig metode for lærerstudenter.* Cappelen Damm Akademisk
[21] Thagaard, T. (2013). *Systematikk og innlevelse: en innføring i kvalitativ metode* (4. utg.). Fagbokforlaget.