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Published in:
Sustainability

DOI:
10.3390/su11051478

Publication date:
2019

Document Version
Publisher's PDF, also known as Version of record

sustainability

MDPI

Article

Systems Thinking Skills of Preschool Children in Early Childhood Education Contexts from Turkey and Germany

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Received: 28 December 2018; Accepted: 6 March 2019; Published: 11 March 2019

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Abstract: This study presents an attempt to contribute to the field of Education for Sustainable Development (ESD) by conceptualizing systems thinking skills of four- to six-year-old preschool children with the role of age in this particular skill. For this purpose, we developed and tested a method and instruments to assess and conceptualize systems thinking skills of 52 preschool children in early childhood education contexts from Turkey and Germany. By employing qualitative case study research, we concluded that the young children showed some signs of complex understanding regarding systems thinking in terms of detecting obvious gradual changes and two-step domino and/or multiple one-way causalities, as well as describing behavior of a balancing loop. However, their capacity was found to be limited when it comes to detecting a reinforcing loop, understanding system mechanisms by acknowledging the unintended consequences, detecting hidden components and processes, demonstrating multi-dimensional perspective, solving problems through high-leverage interventions, and predicting the future behavior of the system. Age had a notable effect on the total systems thinking mean scores of the participants.

Keywords: systems thinking; preschool children; early childhood education; education for sustainable development

1. Introduction

1.1. Systems Thinking in an Increasingly Complex World

Today´s global system is shaped by numerous political, economic, social, and ecological challenges leading to an ever-increasing complexity our society has to deal with. In response to these challenges, insights into the need for change seem to gain real momentum. This is manifested, for example, in the recently ratified Agenda 2030, a globally binding agenda that formulates 17 Sustainable Development Goals (SDGs) that are to be reached by 2030 [1].

To address these SDGs and to recognize and respect the interconnectedness and indivisibility of them, a call for systems thinking figures prominently both in the public and academic discourse. Accordingly, UN Chief Executives' Board for Coordination describes systems thinking as a key way of working and an essential leadership characteristic [2]. Likewise, the Governance Directorship of the Organisation for Economic Co-operation and Development (OECD) declared in 2018 that "the time for piecemeal solutions in the public sector is over" (p. 61), and they suggested the application of systems thinking to bring about innovative solutions to cross-cutting and complex issues [3], whereas a report by the International Council for Science [4] underscored the need for an enormous shift toward systems thinking for coordinating the SDGs.

In the academic discourse on Education for Sustainable Development (ESD), various models of key competencies for sustainable development evolved and have been widely implemented [5–13]. Throughout these models, some variation exists, but systems thinking is unanimously regarded as one of the key elements. This is also echoed in the more general educational discourse where a systems thinking approach is seen as a necessary and promising perspective [14–17], which will especially help children to understand and appreciate the complexity and tensions existing in sustainability-related issues [18].

For this reason, over 20 years, K–12 educators around the world have been integrating systems thinking and dynamic modeling into the curriculum and aligning systems thinking concepts and tools with educational programs [19]. These classroom applications have demonstrated that systems thinking helps students to further their critical thinking and problem-solving skills [20]. In the systems thinking classroom learning environment, children have the opportunity to practice problem-solving attempts, they are exposed to interdisciplinary connections, and they are urged to make in-depth analysis through though-provoking dialogues [21]. Accordingly, attempts to understand young children's skills related to sustainability issues have become a significant interest in promoting sustainable living [22].

In the literature concerning systems thinking, there are contradictory statements related to the nature of young children. Some scholars [21,23–27] argue that children are innately systems thinkers, who can perceive interdependencies and interrelationships well before they are educated in these ideas. This perception is challenged by various authors; for example, Hiller, Remington, and Armstrong [28] argue that children need to expend an extra effort in order to acquire that skill. Similarly, Sweeney and Sterman [19], in their research with 29 middle school students, found that a significant number of participants, regardless of age, exhibit limited understanding of complex natural and social systems. This resonates well with the insight that even well-educated adults have insufficient systems thinking skills [19,29–31].

Consequently, many authors have argued that the research about systems thinking and teaching in this approach is still at an early stage and more robust insights into the development of systems thinking competency are needed [32–37]. This study presents an attempt to contribute to that need by conceptualizing systems thinking skills of children with the role of age in this particular skill. For this purpose, we developed and tested a method and instruments to assess and conceptualize systems thinking skills of four- to six-year-old preschool children by focusing on the following research question: What are the current level of systems thinking skills of four- to six-year-old preschool children in early childhood education contexts from Turkey and Germany across eight different aspects of systems thinking?

1.2. Theoretical Background

Systems thinking was created as a reaction to the reductionist approach which considered that a whole system could be understood by means of analysis of its parts [38]. Senge [15] defined systems thinking as a discipline for understanding the system as a whole, a framework for identifying the relationships in the system and a set of principles and techniques to obtain a sense of the interrelationships. Likewise, some scholars [39,40] articulated systems thinking as a framework that involves perceiving the big picture, understanding complex systems and relationships. Accordingly, a systems thinker is an individual who can understand complex systems, identify the multiple casual relationships within the system, detect the possible side effects of problems caused by short-term solutions, and think through long-term consequences [41]. According to other researchers [29,42], systems thinking is comprised of cognitive abilities, such as thinking in dynamic process, and has a comprehension of the dynamic complexity, distinguishing non-linearity in the system, as well as an understanding of the stock and flow relationships. These conceptualizations demonstrate that rather than being a single skill, systems thinking is a combination of various skills or a set of competencies [43].

In our research, since there is a limitation in terms of conceptualization of systems thinking skills at preschool level, we reviewed the literature on systems thinking skills of adults in general, and elementary and high school children in particular. Based on this literature review, we decided to focus on eight aspects of the systems thinking discipline (see Table 1 for the aspects).

Table 1. Aspects of systems thinking developmental rubric for K-level.

1. Hidden dimension	5. Seeing the whole
2. Recognition of causality	6. Understanding systems mechanisms
3. Identifying and understanding feedback	7. Future prediction
4. Understanding dynamic behavior	8. Identifying intervention points

The first aspect is the ability of recognizing the hidden dimensions of a system. This aspect was adapted from the systems thinking hierarchical model [44] and Richmond's definition of systems thinking. Ben-Zvi Assaraf et al. [44] pointed out that understanding the hidden dimensions of a system is related to noticing patterns and relationships that are not readily seen in the first instance. It was Barry Richmond who first came up with the systems thinking term, defining systems thinking as the science of making dependable extrapolations about behavior of systems by developing an increasingly deep understanding of underlying components and structures [45].

The second aspect, namely the ability of recognition of causality, was derived from the systems thinking definitions that put forward the idea of interconnections [46–49]. Arnold and Wade [46] defined this as the fundamental aspect of systems thinking. This skill involves the ability to identify multiple connections between parts of a system [41].

Identifying and understanding feedback is the third aspect in which "reinforcing and balancing feedback are the two basic circular structures that describe how systems evolve over time" [50] (p.46). When a change occurs within something, over time this change returns to evoke a further change in that very thing; then, a feedback loop emerges. A positive or reinforcing loop (R-loop) emerges if that further change is in the same direction. A negative or balancing loop (B-loop), also called a goal-seeking loop, emerges when it is in the opposite direction [27]. Systems thinking requires identifying those feedback loops and understanding how they impact on system behavior [19,29,46–49,51], since "most complex problems arise from combinations of two or more reinforcing and/or balancing feedback processes" [50] (p.52).

The fourth aspect refers to understanding dynamic behavior. "Interconnections, the way they combine into feedback loops, and the way these feedback loops influence and consist of stocks, flows and variables create dynamic behavior within a system" [46] (p.677).

The fifth aspect is seeing the big picture, which originated from Barry Richmond's forest thinking [45] and Senge's whole thinking [15]. Richmond proposed that people who adopted systems thinking demonstrate the ability to see both the forest and the trees. Peter Senge, another pioneer in the field, distinguishes systems thinking as a discipline which favors seeing wholes and is a framework for identifying interrelationships rather than concentrating on things, for seeing patterns of change rather than static snapshots [15].

Understanding systems mechanisms is the sixth aspect which includes a comprehension of unintended consequences, dynamism, non-linearity and complexity in the systems and was created as a combination of different systems thinking approaches [29,51,52].

The seventh aspect is related to the ability to look at time in a more longitudinal way and was adapted from the framework developed by Ben-Zvi Assaraf et al. [44], UNECE [11], "linking thinking" [53], and the work of Ackoff [54]. Understanding the behavior of a system requires differentiating the interaction of its components over time [29]. This facet entails the capacity to build relationships among past, present, and future, as well as embracing the fact that it is difficult to foresee the future behavior of systems.

The last aspect involves the identification of intervention points which mainly stems from the work of Meadows [47]. Leverage points are places within a complex system where a small shift in one item can lead to considerable changes in all things. These points are basically used to solve complex problems occurring in complex systems. It is difficult to find high-leverage intervention points which will create the most effective intended impact, because this skill requires mastering the system in time and space dimensions via a rigorous analysis of the system.

1.3. Study Context

This research is part of an international study, which includes contrasting cases from Turkey and Germany. We observed significant differences in the implementation of both systems thinking approaches and ESD in Turkey and Germany that might produce more insightful implications for researchers, policy makers, and educators in the field.

While interest in sustainable development has been growing, it is generally agreed that ESD is still in its early stages in Turkey [55,56]. This is supported by national implementation reports submitted by Turkey to the UNECE Steering Committee for ESD in 2007, 2010, and 2015 [57]. Thus, it is possible to trace the concrete consequence of adopting this perspective in the early childhood education (ECE) curriculum in the form of a separate section for ESD; e.g., in the Berlin State ECE curriculum (*Berliner Bildungsprogramm*), in which the German case studies are positioned. Teachers have been introduced to the concept of ESD, and professional development is in place. Differences between Turkey and Germany can also be seen when it comes to systems thinking. The importance of systems thinking in education has been long recognized in Germany; however, the subject has only recently begun to receive attention in Turkey.

There are also differences between these two countries in terms of the history of ECE, as well as ECE participation patterns. Kindergartens and nurseries in Germany were first established in the 19th century [57] and this service continues to be publicly funded and privately delivered. In Germany, according to the defined legal entitlement, three-year-old children are supposed to start ECE and will receive this service for 40 h per week [58]. In Turkey, it was only in the 1990s that ECE programs began to be conducted through institutionalized mechanisms [59]. In contrast with Germany, there is no legal entitlement defined for ECE in Turkey, which means that this service is not compulsory and not accessed by most children [58]. However, it should be noted that there is an attempt to make it obligatory that children in Turkey receive one-year ECE before starting primary school.

2. Method

This study employs a qualitative multiple case study approach to conceptualize systems thinking skills of four- to six-year-old preschool children in early childhood education contexts from Turkey and Germany across eight different aspects of systems thinking.

2.1. Participants and Setting

Convenience and purposeful sampling methods were used to identify and recruit the child participants of the study. Since the level of education of the parents is one of the most significant influences on the cognitive development of a child [60], highly educated parents tend to provide environments with more intellectual stimuli for their children [61–63]. On this basis, it was decided to work with the children of university educated parents since the systems thinking skill is considered as a higher-order cognitive skill. Although the aim was to keep the socio-economic levels of children as similar as possible when carrying out the sampling, this was not perfectly realized. The evident difference in the income inequality and the differences in social and educational policies between the two countries are the reasons behind this limitation. Germany has a more egalitarian structure in income distribution than Turkey in terms of the instrument known as the Gini coefficient, which is used as a measure of inequality. This is one of the factors that also homogenize the social socio-economic level distribution. ECE in Berlin is subsidized by the state and education is free of charge and families generally send their children to the institutions that are closest to their residence or workplace. The socio-economic profiles of families display a particularly diverse picture, especially in centralized neighborhoods. The child of an artisan who works in a small shop and a child of a highly trained white-collar family residing in the same neighborhood benefit from the same preschool education and care services. Thus, the socio-economic levels of the families of children who attend the same preschool have a heterogeneous structure as the family's financial status is not the criterion for the child to be accepted by the preschool. In Turkey, well-educated families, more likely to be members of the middle and upper socioeconomic segment of society, often send their children to private preschools while children who attend state preschools are more likely to be from lower and middle socioeconomic families. Due to this structural difference between the two countries, it has not been possible to form a homogenous sample regarding the educational level of the parents of the children participating in the study.

Data collection focused on two preschools in Turkey (one in Istanbul, the other in İzmir) and two preschools in Germany (both located in Berlin). In both countries, one mainstream preschool and one alternative education preschool that can be considered as having adopted the ESD approach, which is likely to support systems thinking, were included in the study. In this study, a system of action, namely a preschool group with the oldest children was chosen as the unit of analysis. After collecting data from the mainstream Germany preschool, we concluded that the performance of the children belonging to this case was better than the other cases and we decided to collect data from the other learning group in the same preschool in order to reveal more understanding on the chosen phenomenon. Thus, 52 children from five cases participated in the study. Table 2 details the socio-demographic specifics.

Table 2. Profile of participants.

	Characteristics	Frequency	Percentage
Gender	Girls	27	51.9%
	Boys	25	48.1%
Age	48-59 months old	17	32.7%
	60–71 months old	27	51.9%
	72+ months old	8	15.4%
Bilingual	Yes	12	23.1%
	No	40	76.9%
Education level of one of the parents	University degree or above	41	78.8%
	Less than university degree	11	21.2%
Mean ECE enrolment age	28 months old		
Mean age	62 months old		

Note: N = 52.

2.2. Instruments

Child Story and Child Interview Protocol

To explore the details of children´s systems thinking skills, an individual story reading session was planned and administered in each case study, followed by individual semi-structured interviews. The reading session was based on "The Water Hole" written and illustrated by Graeme Base [64], a fictional children's story that draws on basic concepts of systems in an ecosystem context. The book has been positively evaluated for its potential to embed different systems thinking components and characteristics by covering conceptions of interconnections, stocks and flows, behavior over time, and feedback [65], and has been used in similar studies [66].

"The Water Hole" was designed on the limits to growth archetype. According to this systems archetype (Figure 1), growth processes are naturally inherent limits to growth. It is important to identify these limits to avoid problems in future, whether the problem is overpopulation (growing number of the animal population), increasing demand for water (consumption patterns) or an unfair distribution of water (previous comers consume more, latecomers consume less). This means that there should be an understanding among animals that there is a limit to growth and something should be done before all the water has been used. Excessive growth in the face of a limit often leads to collapse (deserting and abandonment) as was the case in the story that was read to the children.

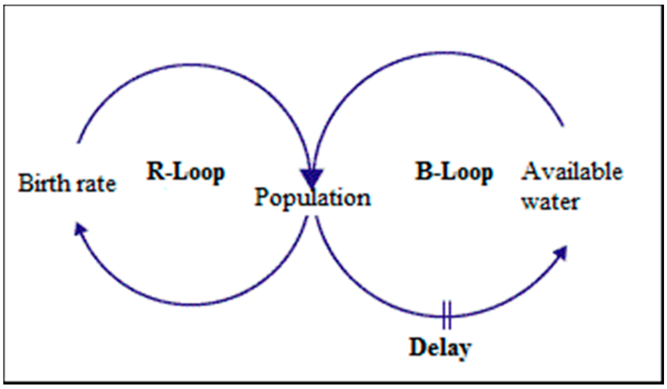

Figure 1. Feedback loops diagram in the story "The Water Hole".

Following a strict child interview protocol, the participants were asked 19 questions directly related to the characteristics of systems thinking skills. Interview questions were derived from previous work [27,67–71] and were complemented by additional questions for this study (see Appendix A for the complete interview protocol). Interview protocol and the child story were prepared in Turkish by the principal investigator, who is a native Turkish speaker, trained as a preschool teacher and has extensive experience with ESD projects in Turkey and translated into German by a native speaker using different quality measures for cross-cultural studies including back-translation [72,73]. Both versions of the story and the interview protocol underwent an expert review and then piloted. The principal investigator realized the interviews with children in the Turkish settings, while a native German preschool teacher, trained by the principal investigator, conducted the interviews in the German setting with the presence of principal investigator.

Ethical approval of the instruments was provided by the Human Research Commission of Middle East Technical University with 28620816/452 ethical approval code. All the children had obtained written consent forms from their parents to participate in the interviews and verbally consented to participate themselves. The interviews, lasting 10–15 min, were audio-recorded and transcribed. The interview text and coded material was translated into English for reporting purposes.

2.3. Systems Thinking Assessment Rubric

To measure children's systems thinking skills, a systems thinking developmental rubric for K-level was created as an assessment rubric by focusing on those eight aspects of systems thinking that are most relevant to the early childhood period and are considered as the building blocks of systems thinking of young children (see Appendix B for the full version of the instrument).

An initial version of the assessment rubric was based on previous studies [19,70,74–79]. The pilot of the rubric underwent an expert review by a panel of six educators, experts and researchers who were early childhood educators, academicians and experts in the field of systems thinking and education for sustainability. Based on their feedback, a final version of the instrument was prepared and utilized in data analysis procedure.

2.4. Data Analysis

In a mixed method approach, the data obtained from child interviews was analyzed through qualitative content analysis [80]. That analysis further developed the pre-determined four levels of each of the eight aspects of the assessment rubric. Then, the data was coded according to the latest version of the assessment rubric by assigning the responses of the children to one of the four levels of each of the aspects of the assessment rubric translating the qualitative into quantitative data, thus calculating a total score for each child. The final step of translating the data in numeric information was checked for inter-coder reliability by coding 25% of the data by a second researcher. Inter-coder reliability was between .91 and .93 for each aspect, discrepancies were discussed and resolved.

3. Results

Findings based on the systems thinking developmental rubric for K-level first revealed the total score the children obtained and the scores for each of the eight aspects and qualitative insights in each aspect. The children scored between 2 and 19 points from a possible total maximum of 24. Table 3 shows how the average of the scores correlates with age.

Table 3. Scores according to the ages of participants.

	48–59 Months Old	60–71 Months Old	72+ Months Old
Frequency	17	27	8
Mean Scores	10.05	11.77	14.12

Note: N = 52.

The average scores of the cases varied between 9.83 and 13.44 points. Table 4 shows the scores and ages across cases.

Table 4. Scores and ages of the participants according to the cases.

	Mainstream Case Turkey	Alternative Case Turkey	Alternative Case Germany	Mainstream Case Germany-1	Mainstream Case Germany-2
Mean Scores	9.83	12	10.13	13.44	12.71
48–59 months old	7 participants	5 participants	5 participants	-	-
60–71 months old	5 participants	4 participants	2 participants	7 participants	9 participants
72+ months old	-	-	1 participant	2 participants	5 participants
Mean Ages	57 months old	59 months old	58 months old	67 months old	67 months old
Sample Sizes	12	9	8	9	14

Note: N = 52.

The details of the results from the aspects presented in Table 1 are given in the following text.

3.1. Hidden Dimension

One of the characteristics of the systems thinker is exposing hidden dimensions of the system by recognizing components, processes, patterns, and relationships [67]. Connecting the obvious with the hidden allows better understanding the system structures, and this provides an opportunity to develop lasting solutions which are integrated into the whole system rather than short term solutions [81]. Interviews with the children aimed to explore their abilities to look beyond the seen and work with hidden dimensions. Accordingly, they were asked five different questions: “Where did the water come from?”; “Why did the water decrease?”; “Where did the water go?”; “Where did the animals go?”; and “Who/what else needs/uses water?”

As revealed in Table 5, six children only mentioned the obvious components and processes (Level 1). Twenty-two child participants’ responses were labeled as having a lower level of hidden components (Level 2) since they were only able to identify up to two hidden components while providing responses to the above-mentioned five different questions. Fifteen children identified more than two hidden components (Level 3), and nine children mentioned possible hidden processes in addition to hidden components (Level 4).

Table 5. Hidden dimension.

Characteristics	Frequency	Percentage
Level 4—Hidden processes	9	17.3%
Level 3—Higher level hidden components	15	28.9%
Level 2—Lower level hidden components	22	42.3%
Level 1—Obvious components and processes	6	11.5%

Note: N = 52.

In order to provide more insight into the abilities of children in terms of hidden dimension, their responses to the questions of "Where did the water come from?"; "Why has the water decreased?"; and "Where did the water go?" are also given (see Tables 6–8). Focusing on the question of where the water pictured at the beginning of the story might have come from, 20 children (38.5%) did not give a valid response, two of the 32 children gave two answers to this question; thus, a total of 34 responses were evaluated. As displayed in Table 6, the water came from rain (52.9%), from another source such as the ocean, the sea or lake (26.5%), and underground (20.6%).

Table 6. Where does the water come from?

Code	Frequency	Percentage
Rain	18	52.9%
From another resource such as the ocean, sea, or lake	9	26.5%
Underground	7	20.6%

Note: Number of valid responses = 34.

Table 7. Why did the water decrease?

Code	Frequency	Percentage
Because it was drunk	32	72.7%
It went underground	4	9.1%
Evaporated	3	6.8%
Due to the lack of rain	2	4.6%
Something at the bottom (beaver and magnet) pulls the water down	2	4.6%
There may have been a fire	1	2.3%

Note: Number of valid responses = 44.

Table 8. Where did the water go?

Code	Frequency	Percentage
Drunk by animals	29	60.4%
Went underground	11	22.9%
Went to the sea	1	2.1%
Evaporated	1	2.1%
Other responses (irrelevant to the story but meaningful in general)	6	12.5%

Note: Number of valid responses = 48.

Focusing on the question of "Why did the water decrease?", the children were asked to provide possible reasons for the gradual decline of the water. Nine children stated that they did not know the answer to the question, and another two children said that the water was running out because the pages of the book were turned. Three children submitted more than one justification, and in total 44 valid responses were obtained. As demonstrated in Table 7, the most popular of the children's responses to the question was that the water was drunk by animals (32 responses). Other replies were the water went underground (four responses), it might have evaporated (three responses) and because it did not rain (two responses). Two children thought that something at the bottom of the water hole (beaver and magnet) pulls the water down. One child thought that a fire in the forest caused the gradual decrease of the water. Thus, according to the data in this section, it appears that the children's responses are dominantly focused on the obvious event of drinking the water.

Concerning the question about where the water may have gone, children gave responses similar to those they provided to the previously explained question. Forty children gave responses related to the story, a further six children gave responses that were not related to the story but which can be considered meaningful (for example, one child thought the water was carried to a pool), and six children said, "I do not know" or remained silent. Two children offered two responses to this question, and the total number of valid answers was 48. As displayed in Table 8, the most frequent response was "the water was drunk by animals". Eleven children stated that the water went underground. One child said that the water disappeared due to evaporation, and another child stated that the water went to the sea. Six children's responses were evaluated under the code of "other responses".

The responses related to the hidden dimension of systems thinking revealed the young children's limitations on the content knowledge and below-the-surface thinking.

3.2. Recognition of Causality

Systems thinking is characterized by the ability to deal with complexity in causal patterns. Although what is expected from real systems thinkers is to go beyond one-way causalities, we decided to elaborate young children's one-way causality building abilities as this is seen as the first step of understanding causalities and correlations.

As shown in Table 9, all the children were able to build up a linear cause-and-effect relationship. Fourteen built a one-way relationship between one cause and one effect (Level 2). Thirty-six children went further and described either two-step linear connections that result in direct and indirect effects or multiple one-way simple causality (Level 3). This means that they were able to detect multiple causes and/or multiple effects; e.g., A and B are causes of C, and/or D causes E and F. Only two children reached Level 4 by expressing a three- or more-step domino causality as in this example extract: "If there is no water, we can't wash our hands. Then, there will be bacteria all over our body and we will get sick".

Table 9. Recognition of causality

Characteristics	Frequency	Percentage
Level 4—Three or more-step domino causality	2	3.9%
Level 3—Two-step domino causality OR Multiple one-way simple causality	36	69.2%
Level 2—One-way simple causality	14	26.9%
Level 1—No causality	0	0%

Note: N = 52.

3.3. Identifying and Understanding Feedback

Feedback thinking acknowledges the role of feedback loops in causal webs [19]. Accordingly, we evaluated children´s ability to detect behaviors in a system that can feedback to form positive and negative processes (see Table 10). In our study, 17 children were able to close the loop between two components in the system by recognizing the simple interdependence between the animals and the water (Level 2), while six struggled with the concept of feedback loops (Level 1). Around half of the children were able to trace causal relationships around the loop and describe the behavior of one feedback loop, noting that the oscillating behavior continues to bounce off each relationship over time (Level 3).

Table 10. Identifying and understanding feedback.

Characteristics	Frequency	Percentage
Level 4—Multiple closed loops	2	3.9%
Level 3—Behaviour of closed loop over time	27	51.9%
Level 2—Closed loop	17	32.7%
Level 1—Open loop	6	11.5%

Note: N = 52.

Although the children were clearly aware of population growth in the story, they did not extend their explanations beyond the visible level and did not focus on population growth, which was one of the root causes of the problem, while they were dealing with causal relations. Only two children reached Level 4 by describing the behavior of a balancing and a reinforcing loop. For example, the child who presented sophisticated responses to most of the systems thinking aspects on which this study focused said that to solve the water scarcity problem presented in the story, he would take control the number of animals by hunting some of them.

3.4. Understanding Dynamic Behaviour

The children were expected to identify the dynamic nature of water by describing the regular decrease in the amount of water that occurred during the story, as well as its disappearance and re-existence. The nature of the water throughout the story that was read is the most visible dynamic behaviors in the system that arise from the interaction of a system's components over time.

As shown in Table 11, only one child did not notice any change in water (Level 1). Eight children recognized the back-and-forth movement of the water; however, they could not define the gradual change on the amount of water (Level 2). From their perspective, the water increased and decreased from time to time or its color changed. The majority of the children were aware of the gradual change of the amount of water; in other words, they could differentiate the water hole as a stock variable (Level 3). Only four children were able to detect a circular dynamic behavior pattern which requires taking into account both obvious and hidden components and processes (Level 4) with one of the children being able to describe a water cycle: "Because the sun is drying the water, a little water goes up, into the clouds. Then, it comes down again as rain, comes up from the underground".

Table 11. Understanding dynamic behavior.

Characteristics	Frequency	Percentage
Level 4—Hidden pattern	4	7.7%
Level 3—Obvious gradual change	39	75%
Level 2—Obvious sudden change	8	15.4%
Level 1—No change	1	1.9%

Note: N = 52.

3.5. Seeing the Whole

To estimate how far children were able to perceive the whole, or in other words, looking at the big picture, we asked "what was this story about?" and "give the book a title" to measure their ability to comprehend a given issue from multiple and holistic dimensions.

As shown in Table 12, four children either did not respond to these two questions or gave irrelevant answers; however, 24 children provided responses to both questions that focused on one dimension in the story, such as "the story is about the water" and "title of the book can be the animals" (Level 2) because they focused primarily on the resource or the users in the story. When a child provides problem-oriented or habitat-oriented or a combination of user-and-resource-oriented responses, then this response was considered as a multi-dimensional perspective. Nineteen children gave responses that were evaluated as partially multi-dimensional because they provided one multi-dimensional answer to one of both of the questions (Level 3). For example, one child stated that the story is about a water hole and the title of the book could be "The Dehydrated Animals". Five children displayed advanced skills by providing two multi-dimensional responses to both of the questions and demonstrated a relatively more holistic perspective toward the issues (Level 4). According to a child who performed at this level, the story is about "animals that want to drink water but they can't achieve this", and the title of the book can be "The Drought".

Table 12. Seeing the whole.

Characteristics	Frequency	Percentage
Level 4—Full multi-dimensional perspective	5	9.6%
Level 3—Partial multi-dimensional perspective	19	36.5%
Level 2—Uni-dimensional perspective	24	46.2%
Level 1—No response	4	7.7%

Note: N = 52.

3.6. Understanding System Mechanisms

Systems thinking requires understanding a system structure that involves components and interrelationships between those components. In this aspect, we captured the children´s perspective on how the system could be affected if a new component was added.

Table 13 shows that 20 children were able to display a limited understanding of the system mechanisms in that they could only anticipate a potential local impact of adding the new component to the system; e.g., humans will use the water, they will scare the animals, or they will take care of the animals (Level 2), while 11 could not foresee any change (Level 1). Another 20 children described the wider impact of adding the new component to the system, stating that people would be included in the system as an additional user of the water (Level 3). Only one child also considered the possibility of unexpected changes in the system (Level 4).

Table 13. Understanding system mechanisms.

Characteristics	Frequency	Percentage
Level 4—Unexpected impact	1	1.9%
Level 3—Broader anticipated impact	20	38.5%
Level 2—Limited anticipated impact	20	38.5%
Level 1—No change or no response	11	21.1%

Note: N = 52.

3.7. Future Prediction

Many living systems do not display the full cycle of their behavior within short time periods. As this viewpoint develops, only observing the current state of the behavior of the system is not sufficient, and it will appear that past behavior and the possible future behavior must be included. In order to contribute to the evaluation of the time aspect of systems thinking, the children were asked to predict what might happen in the story. The main aim of the assessment in this part was to detect the children's ability of prediction, use of short-term and long-term time intervals, and understanding how the system functions over time.

As shown in Table 14, one-third of the participants (n = 16) were either unable to continue the story or provided irrelevant responses (Level 1). A significant number of children (n = 28) constructed their future predictions on the existing pattern with a feedback loop of water availability and animal appearance (Level 2). Eight children positioned the story in a larger time interval (Level 3), for example, by stating that the water would be consumed every time it appeared, and after some time water would be gone forever or animals would be more careful this time, and that water would not end as a result of this cautious behavior. None of the children in the current study reached the level of sophistication, which embraces the mess perspective when approaching systems (Level 4).

Table 14. Future prediction.

Characteristics	Frequency	Percentage
Level 4—Messes perspective	0	0%
Level 3—Broader time dimension	8	15.4%
Level 2—Limited time dimension	28	53.8%
Level 1—No or irrelevant response	16	30.8%

Note: N = 52.

3.8. Identifying Intervention Points

By recalling the decreasing and disappearance of the available water, the children were asked "how would you solve this problem if you were one of the animals in this story?". Rather than being a third-party helper, the children were asked to identify themselves with an animal in the story and find a solution to the inadequate water amount problem.

As depicted in Table 15, 12 children either left the question unanswered or offered irrelevant responses (Level 1), while another 12 children explained that it was not necessary to do anything because the water would come back (Level 2). Twenty-two children provided responses that were categorized as "low leverage of interventions" because they provided a quick fix approach to the problem, such as increasing the amount of water or reducing or suspending water consumption (Level 3). Those 22 children were not aware that those solutions would create new problems. Six children offered solution proposals which were scored as "high-leverage interventions" because those responses demonstrated a longer term diagnostic approach by focusing on the possible root causes (reinforcing feedback loop) or offering more sophisticated intervention points, such as acting in time before the water fully dried up (being aware of the delay in the system) or distributing the resource fairly (Level 4). The following interview excerpt offers an exemplary approach for this level: "Before the water was completely exhausted, I would gather all the animals together and we would discuss together who could help us."

Table 15. Identifying intervention points.

Characteristics	Frequency	Percentage
Level 4—High leverage of interventions	6	11.5%
Level 3—Low leverage of interventions	22	42.3%
Level 2—Doing nothing	12	23.1%
Level 1—No or irrelevant response	12	23.1%

Note: N = 52.

4. Discussion

The findings of this study indicated that the young children showed some signs of complex understanding regarding systems thinking in terms of detecting obvious gradual changes and two-step domino and/or multiple one-way causalities, as well as describing behavior of a balancing loop. However, their capacity was found to be limited in detecting a reinforcing loop, understanding system mechanisms by acknowledging the unintended consequences, detecting hidden components and processes, demonstrating multi-dimensional perspective, solving problems through high-leverage interventions, and predicting the future behavior of the system.

The mean scores of the children exposed to different educational experiences in two contrasting pedagogical environments in two different countries provided an extended understanding of young children's abilities and supported the findings showing young children's limitations regarding exhibiting systems thinking. Not surprisingly, age had a notable effect on the total systems thinking mean scores of the participants. As the age of the children increased, the mean scores also increased. Recent studies exploring how the child's mind functions highlight the executive function (EF) of the brain which has a role in the development of complicated analytical thinking [82]. Complex skills, such as planning, monitoring, task switching, and controlling attention are among the functions of EF [83,84]. In the explanation of analogical capacity in children, the role of inhibitory control, as well as manipulation and organization of complex information while holding it active in the working memory have been underscored by brain researchers [85–87]. Throughout life, EF continues to play an indispensable role in the arc of reasoning skill, increasing with age in childhood [88]. Parallel to the findings of the current research, age plays a significant role in the development of the EF capacity [89,90].

In the current study, it was concluded that the children approach the issues horizontally (time-wise) and vertically (space-wise) in a limited fashion. This finding is supported by a meta-analysis performed across 50 independent studies indicating that the greater spatial or temporal discontiguity results in poorer learning outcomes especially when the learning material is rather complex [91]. The nature and extent of the knowledge base of children, including their conceptual, relational, and conditional knowledge, is a significant parameter that should be evaluated when defining children's reasoning ability [92,93]. In this research, it was revealed that the participants did not have comprehensive knowledge about the issues presented to them when read a story, and as explained by Sweeney and Sterman [19], if individuals do not have a systems-specific content knowledge, they tend to focus on surface features. In relation to connecting causes and distal effects, providing content knowledge helps children produce more comprehensive narratives [94]. One alternative approach to young children's limitations regarding exhibiting systems thinking is related to systems thinking not being a natural act. As argued by Valerdi and Rouse [95], this is connected with human evolution since it favors mechanisms tuned to dealing with immediate surface features of problems. Due to the incomprehensible intricacy of some complex systems, a reduction reaction transpires which contains the necessary skills to become a systems thinker. In line with these arguments, Perkins and Grotzer [77] explain that the reason why more complex modeling styles make it harder for learners to understand by arguing that linear relationships can be easily understood because of their familiarity. However, many concepts and theories in systems depend on more complex styles that contradict other relatively more known modeling styles of less complex nature. It is because of such contradictions that we tend to prefer the more simple explanation.

Since the measurement of children's systems thinking skills in this study was reliant on verbal communication, it is imperative to take into consideration the expressive language skills of the preschoolers and the development of EF. Both the EF capacity at the age of 5 and the development of the EF skills between the ages of 3 and 5 are related to the extent to which children's vocabulary grows between the ages of 15 and 36 months [96]. As demonstrated in a study of 191 children between ages of 4 and 6, when the verbal ability is lower, then it can be predicted that the performance level on several EF tasks at the age 4 will also be lower [97]. Similarly, another smaller scale study executed with 39 three- to five-year-old children concluded that it is possible to predict their verbal working memory abilities by assessing at their oral language skills [98]. A study of the verbal ability of Head Start enrollees revealed a correlation between their development in expressive language and EF skills [99].

5. Conclusions

As revealed in this research, young children were limited in terms of demonstrating a complex understanding of systems for the following possible reasons: (1) developmental limitation of children to process system components and processes in a relational way by incorporating broader time and space understanding, (2) limited content knowledge, (3) human nature, and (4) verbal communication abilities of young children. The first reason was also connected with human evolution since it favors mechanisms for dealing with the immediate surface features of problems. "The human mind grasps pictures, maps, and static relationships in a wonderfully effective way. But in systems of interacting components that change through time, the human mind is a poor simulator of behaviour" [24] (p.6). To overcome this problem, utilization of effective tools to enhance young children's systems thinking such as behavior-over-time graphs, causal loops, connection circles, concepts maps, stock/flow maps, and computer programs including simulation models in educational settings is this study's first implication for educational practices. In this context, we offer a new approach to education which brings together a paradigm shift from fragmental, mechanistic and reductionist educational approaches to more holistic, interactionist and multifaceted educational approaches. Current educational contexts are lacking in terms of providing learning and development opportunities that improve the systems thinking skills of young learners. Accordingly, we suggest that early childhood educators should become competent in terms of utilizing the available systems thinking tools that are available for young learners. In this context, this research strongly recommends the integration of systems thinking into pre- and in-service teacher training programs.

Another implication derives from content knowledge characteristics of the young children. Helm [100] utilized the circular diagram by Bess-Gene Holt's concept of "distance from self" [101]. By the use of three numbered circles (see Figure 2), the topics that are more likely to deeply engage children in line with their developmental levels are demonstrated. According to this numbering mentality, the first circle includes topics relevant to the world of the young child. The second circle (which also contains the topics in circle 1) includes topics that are meaningful to the preschooler. The third circle (which includes everything in circles 1 and 2) demonstrates topics relevant to the immediate world of the preschooler and first-grader. We argue that creating environmental literacy learning opportunities involving reasoning exercises across large spatial scales and socio-ecological systems [102,103] assisted by this diagram may expand young children's content knowledge repertoire related to systems thinking.

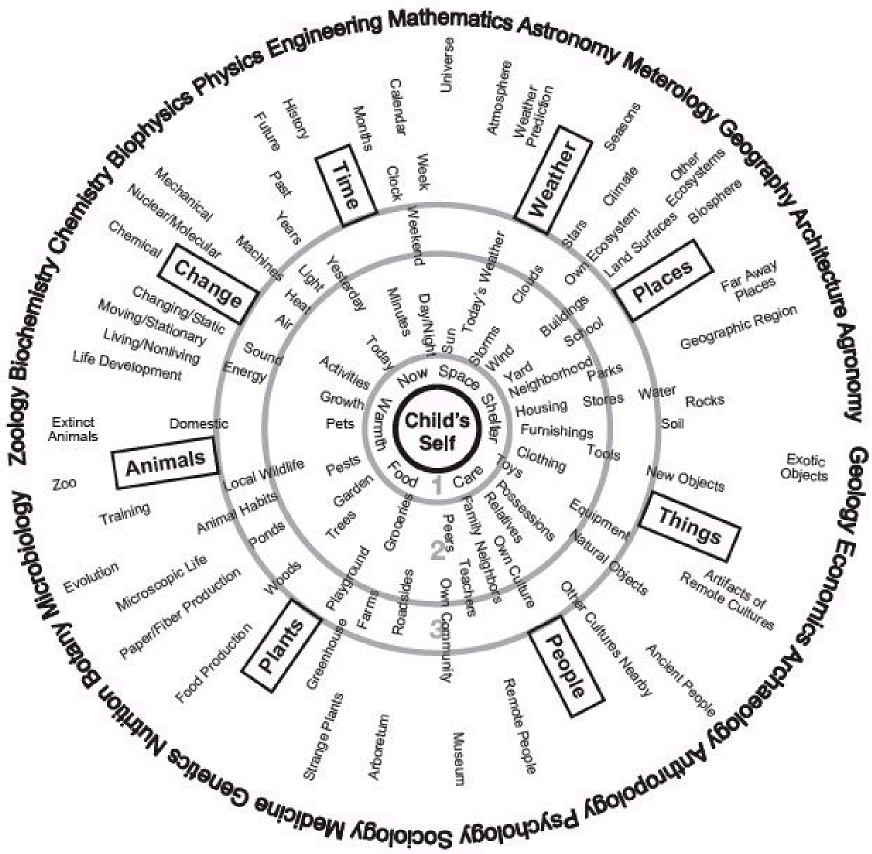

Figure 2. Distance from self diagram [100] (p.51).

Again, in relation to the developmental characteristics of children, this study argues that the work within the scope of systems thinking will produce more effective results with older children in early childhood educational contexts. As this study revealed, through a story reading, it was possible to measure systems thinking skills of young children and we believe that this tool can also be used to enhance this particular skill.

Undertaking cognitive and language development segmentation while sampling is our recommendation for researchers in this field. Adding an observation component as a measurement tool to conceptualize the young children's systems thinking skills is another recommendation for further research studies due to the late development of the expressive language of the targeted age group. Examination of the relationship between the expressive language skills of young children and the education level of their parents is another recommendation for further research studies. Our final suggestion is to replace the water topic with an adapted version of the rubric produced in this research with a theme about which the child participants have very detailed and comprehensive content knowledge.

By targeting researchers working in the field of early childhood education for sustainability, educational policy-makers and teachers as well as young generation, in this study, we aimed to offer them an opportunity to develop a new approach to designing learning experiences to equip children towards resolving contemporary complex and wicked challenges. We hope together with other studies in the field, this work will generate some ideas about a new paradigm which is constructed around "holism, systemic thinking, sustainability, and complexity" [104] (p.64).

Author Contributions: Conceptualization, Funding Acquisition, Formal Analysis, Investigation, Data Curation, Project Administration, Writing—Original Draft Preparation, Ş.F.; Methodology, Validation, Supervision, Writing—Review & Editing, R.O. and G.T.; Methodology, Validation, Supervision, Writing—Original Draft Preparation, M.B.

Funding: This research was funded by Jean Monnet Scholarship Programme.

Acknowledgments: The authors would like to thank Feyza Erden, Jennie Farber Lane, Jeremy Solin and Özgül Yılmaz-Tüzün for their valuable contributions to the study. The reviewers deserve a special thanks for their constructive comments, feedback, and recommendations.

Conflicts of Interest: The authors declare no conflict of interest. The funder had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Appendix A. The Child Story and the Interview Protocol

Down to the secret water hole the animals all come.
As seasons bring forth drought and flood, they gather as one.
United in their common need, their numbers swell to ten.

One rhino
drinking at the water hole.
"Mmm, delicious!"
Interview Question 1: Where did the water come from?

Two tigers
lapping at the water hole.
"Grrrrrrr"

Three toucans
squawking around the water hole.
"It is party time, fellas! Drink it up"

But something was happening . . .
Interview Question 2: Something has begun to change, can you think about what has changed?
What do you think happened?

Four snow leopards
gazing at the water hole.
(We must be careful, brothers)

Five moose
wallowing in the water hole.
(Hey, get your hoof out of my ear!)

The water hole was getting smaller and smaller . . .

Six catfish
floundering in the water hole.
(Blub, blub, blub)

and smaller . . .

Seven pandas
Sipping at the water hole.
(I've already drank my friend, you can drink as well if you want)

Eight ladybugs
meeting by the water hole and chatting.

Nine tortoises
lumbering around at the water hole, which is almost dried up.

Ten kangaroos
looking at the water hole.
There was nothing to say.
The water was all gone.
Interview Question 3: Where did the water go?

And all the animals went away.
Interview Question 4: Where did the animals go?

Then a shadow fell across the sun.
Clouds began to gather.
A single drop of rain fell.

It rained and rained and rained and rained . . .
All the animals came back!

Interview questions posed after reading the story:
5—What was this story about?
6—What did the animals in the story do?
7—Why do you think they did . . . (drink, go away etc.)?
8—Why did the water decrease?
9—What happened when the number of animals increased?
10—What happened when the amount of water decreased?
11—What happened when there was no water anymore? Why did it happen?
12—Where did the animals go?
13—Why did the animals return to the forest?
14—Do some things keep happening over and over in the story?
15—Who/what else needs/uses water? How?
16—What would happen if humans were included in the story?
17—How would you solve this problem if you were one of the animals in this story?
18—Please continue the story. What do you think will happen next? How will the story end?

19—Give the book a title.

Appendix B

The Systems Thinking Developmental Rubric for K-Level

This rubric was developed as a systems thinking assessment tool as part of doctoral research which focuses on the systems thinking skills of four- to six-year-old children living in Turkey and Germany. In total, the data from the interviews of 52 children from Turkey and Germany were analyzed using this rubric.

The child interviews were based on reading them a story ("The Water Hole" by Graeme Base), after which the children were asked questions related to the story. Based on the rubric, the responses of children were analyzed as shown in the tables below and various examples were selected from the interviews and the children's responses.

If a child provided two explanations in which a lower level response was elaborated by a higher-level one, then the higher-level explanation was scored.

For no response or the child answering, "I don't know", no score was given.

The total scores ranged from 0 to 24.

Hidden Dimension

Questions: Where did the water come from? Why did the water decrease? Where did the water go? Where did the animals go? Who/what else needs/uses water?

Main assessment aim: To measure the children's ability to detect obvious and hidden components and processes in the system.				
Level 1 (Score = 0)	Level 2 (Score = 1)	Level 3 (Score = 2)	Level 4 (Score = 3)	Inclusion/exclusion criteria
Obvious Components and Processes: The child only describes obvious components and processes. The child is not aware of the hidden components and/or processes. Example: Animal, water, rain.	Lower Level Hidden Components: The child identifies up to two hidden components Example: Flowers, human beings, sun	Higher Level Hidden Components: The child identifies more than two hidden components Example: A beaver (the child created a theory: there is a beaver under the water hole and it withdraws water from it), or something under the water, flowers, trees	Hidden Processes: The child describes hidden processes. Example: "The sun dries up the water" or "water comes from or goes underground".	The child is expected to provide both hidden components and processes to be scored as Level 4.

Recognition of Causality

Why do you think animals did . . . .? What happened when there was no water anymore? Why did it happen? Why did the animals return to the forest?

Main assessment aim: To assess the connections that children see in the story considering whether they detect the domino causality and multiple causality, as well as direct and indirect connections.				
Level 1 (Score = 0)	Level 2 (Score = 1)	Level 3 (Score = 2)	Level 4 (Score = 3)	Inclusion/exclusion criteria
No Causality: The child does not build any linear cause-and-effect relationship. Example: "Animals drink from the water because they want to".	One-Way Simple Causality: The child builds a one-way relationship between one cause and one effect. Example: "There was less and less water available, because animals drank it".	Two-Step Domino Causality: The child describes two-step linear connections that result in direct and indirect effects. Example: "If there is no water, we can't wash our hands. Then, there will be bacteria all over our body". OR Multiple One-Way Simple Causality The child can detect multiple causes and/or multiple effects, such as A and B being causes of C and/or D causing E and F. Since the story openly provides one cause-one effect relationships to children, this level requires abstract thinking. Example: "The amount of water is decreasing because there is no rain, and animals have been drinking it".	One-Way Three or More-Step Domino Causality: The child describes an extended linear pattern that includes a multi-step linear connection of three or more steps with indirect effects. Example: "If there is no water, we can't wash our hands. Then, there will be bacteria all over our body and we will get sick".	The causality responses do not have to be related to the story but they should be considered meaningful. If this condition is not met, then Level 1 should be assigned.

Understanding and Identifying Feedback

Questions: What happened when the number of animals increased? What happened when the amount of water decreased? (in addition to the questions presented in the recognition of causality aspect).

Main assessment aim: To measure the children's ability to detect the behaviors in the system that can 'feedback' to form positive and negative processes.				
Level 1 (Score = 0)	Level 2 (Score = 1)	Level 3 (Score = 2)	Level 4 (Score = 3)	Inclusion/exclusion criteria
Open Loop: The child notices one-way linear connections. The child is not aware of the reciprocal connection between components. Example: "The animals left because the water was gone"	Closed Loop: The child closes the loop by describing the mutual relationship between components (the child explains how one component affects a second component, and how it returns and affects the first component (as in the Waters Foundation document). S/he does not, however, describe the behavior of this feedback structure over time. Example: "When there is no water, then there are no animals. When there is water, the animals come back to the forest (existence of animals depends on the existence of water). Water depletion was caused by the animals (existence of animals affects the water)".	Behavior of Closed Loop over Time: The child closes the loop, continues to trace causal relationships around the loop and describes the behavior of the feedback loop, noticing that the oscillating behavior continues to bounce off each relationship over time (a degree of impact is added) Example: "The more animals come to the water hole, the more they drink the water, and the less water is available, the less the animals remain in the forest".	Multiple Closed Loops: The child describes behavior of a balancing and a reinforcing loop. Example: "The more animals come to the water hole, the more they drink from the water. The less water is available, the less animals stay in the forest (balancing feedback). I would catch some of the animals so that their number won't increase (reinforcing feedback because the child is aware of the fact that population will rise due to the new members)".	-

Understanding Dynamic Behavior

Questions: Something has begun to change, can you think of what has changed? Do some things keep happening over and over in the story?

Main assessment aim: To detect the children's dynamic thinking ability considering whether they can understand changes in the components and processes that construct obvious and hidden patterns in the system.				
Level 1 (Score = 0)	Level 2 (Score = 1)	Level 3 (Score = 2)	Level 4 (Score = 3)	Inclusion/exclusion criteria
No Change: The child does not notice any change in the system components. Example: "Nothing happens to the water".	Obvious Sudden Change: The child notices changes at the back-and-forth or existence-presence level. However, s/he does not describe the dynamic behavior using a gradual time-view. Example: "The water has gone; it came back".	Obvious Gradual Change: The child is able to trace the dynamic behavior noticing that there is a gradual change when a gradual time-perspective was given. Example: "There is less and less water each time".	Hidden Pattern: The child is able to detect a circular dynamic behavior pattern through a much longer time-view and incorporates both obvious and hidden components and processes. Example: "Because the sun is drying the water, a little water goes up into the clouds. Then, it comes down to earth again".	Since this skill stems from the ability to observe the behavior of water within a certain time, children who could not define the gradual change by saying the water increased and decreased from time to time or its color had changed should be scored as Level 2.

Seeing the Whole

Questions: What was this story about? Give the book a title.

Main assessment aim: To measure children's ability to demonstrate a multiple perspective approach and comprehend a given issue through more holistic perspective.				
Level 1 (Score = 0)	Level 2 (Score = 1)	Level 3 (Score = 2)	Level 4 (Score = 3)	Inclusion/exclusion criteria
No Response to Both Questions: The child does not provide any response to either question. Example: "I don't know"	Uni-Dimensional Perspective: The child provides responses to both of the questions that focus on one dimension in the story. Example: "The story is about the water" "Title of the book can be the Animals"	Partial Multi-Dimensional Perspective: The child provides one multi-dimensional response to one of the questions and displays partially more holistic look to issues. Example: The child provides problem-oriented OR habitat-oriented OR combination of user-resource-oriented responses "The story is about the Drought" **OR** "Title of the book can be: animals are lacking water"	Full Multi-Dimensional Perspective: The child provides two multi-dimensional responses to both questions and displays a relatively more holistic observation of the issues. Example: The child provides problem-oriented OR habitat-oriented OR combination of user-resource-oriented responses "The story is about the Drought" **AND** "Title of the book can be: animals are lacking water"	-

Understanding System Mechanisms

Questions: What would happen if humans were included in the story?

Main assessment aim: To detect the children's understanding of the systems mechanisms by adding a new component to the system.				
Level 1 (Score = 0)	Level 2 (Score = 1)	Level 3 (Score = 2)	Level 4 (Score = 3)	Inclusion/exclusion criteria
No change: The child describes that there would be no change in the system. Example: "Everything would be the same".	Local Anticipated Impact: The child describes only the potential local and short-term impacts of the addition of the new component to the system. Example: "Humans could use the water as well". "Humans could scare the animals away". "They could look after the animals, give them water".	Broader Anticipated Impact: The child describes wider and long-term potential impacts of adding the new component to the system. Example: "Humans would use the water, and water would disappear even more quickly".	Unexpected Impact: The child considers the possibility of unexpected changes in the system. Example: "Humans will hunt some of the animals so that there will be enough water for the rest of animals, and none of the animals will have to move to another place. This time, humans will decide to destroy the habitat of the animals. This would make the animals unhappy and they would decide to scare the humans, etc."	The main distinction between Level 2 and Level 3 is to provide multi step prediction response to the question.

Future Prediction

Please continue the story. What do you think will happen next? How will the story end?

Main assessment aim: To detect children's ability to predict, understand an event sequence within an identified time frame, and determine the degree to which one or more elements will change over time and how the system functions generally over time.				
Level 1 (Score = 0)	Level 2 (Score = 1)	Level 3 (Score = 2)	Level 4 (Score = 3)	Inclusion/exclusion criteria
No or Irrelevant Response: The child does not make any predictions related to the future behavior of the system. Example: "Then, the animals swim in the water".	Limited Time Dimension: The child constructs her/his future predictions on the existing pattern. Example: "The water will be consumed by the animals again. The animals will go; then, the water will return, and the animals will come back".	Broader Time Dimension: The child makes future predictions through seeing the issue from a wider perspective, s/he positions prediction in a larger time interval and makes predictions not only based on the existing pattern. Example: "The water will go away, come back, and go away again for some time; then, it will be gone for good".	Messes Perspective: The child grasps how sophisticated the dynamics of even a simple system actually are; so, s/he does not try to foresee how it will act. Example: "I am not sure because it is hard to know".	-

Identifying Intervention Points

Question: How would you solve this problem if you were one of the animals in this story?

Main assessment aim: To detect the children's problem solving ability in a given problematic system behavior. In this context, rather than being a third-party helper, the children are asked to identify themselves with a component in a given situation and find a solution in the operating system.				
Level 1 (Score = 0)	Level 2 (Score = 1)	Level 3 (Score = 2)	Level 4 (Score = 3)	Inclusion/exclusion criteria
Irrelevant or No Response: The child does not provide a valid response. Example: "I would be a kangaroo, and I would jump into the toy box".	Doing Nothing: The child explains that it is not necessary to do anything because the water will come back anyway (gets score because s/he notices the most recognizable pattern regarding the water and bases her/his solution on this pattern). Example: "I would do nothing; the water will come back again. So there is no need to do anything".	Low Leverage of Interventions: The child provides a quick fix approach to the problem, such as increasing the amount of water or reducing or suspending water consumption. S/he is not aware that those solutions will create new problems. Example: "I would do a rain dance so there would be more water". "I would drink less and less water".	High Leverage of Interventions: The child demonstrates a longer term diagnostic approach by focusing on possible root causes or offering more sophisticated intervention points, such as acting in time before the water has fully dried up (being aware of the delay in the system) or distributing the resource fairly. Example: "Before the water was fully-consumed, I would gather all the animals together and we would talk about what to do and who could help us".	Possible responses that should be scored as Level 4 are: changing the rules of the system, changing the distribution of power over the rules of the system, changing the goals of the system, and changing the mindset out of which the system — its goals, power structure, rules— arises.

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