Preschoolers' conceptual development of the plant reproduction cycle

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Plants play a central role in all life on Earth, and it is important to learn about them from an early age. It is important to understand and incorporate children's concepts of biological topics to prevent learning difficulties. This study examines their understanding of the life cycle of flowering plants, as few studies exist on this topic.

A total of 16 children aged 5 to 6 years from a kindergarten in Vienna participated in a pre-, post-, and late-post-study. The children's conceptions of the life cycle of plants were assessed using drawings and group interviews. A four-day intervention, based on the results of the pre-interviews, was designed to support learning towards scientific conceptions.

The children's concepts were a mixture of alternative and scientific ideas about all stages of the life cycle, some of which evolved through the intervention. From the beginning, the children understood that plants grow from seeds and require water and light. As a result of the intervention, most children were able to describe the connection between flowers and fruit. A range of anthropomorphic and anthropocentric perspectives could be observed, particularly regarding seed dispersal, but these decreased following the post-interviews. From the post-interviews onwards, some children recognized the existence of pollen, but at no point were they able to explain the process of pollination.

The children's interest was most effectively stimulated through the use of living plants at different cycle stages, various sensory experiences, and the examination of plants under incident light microscopes.

Rittig N, Scheuch M (2025) Entwicklung der Konzepte von Kindern im letzten Kindergartenjahr über den Lebenszyklus von Pflanzen.

Nachdem Pflanzen eine zentrale Rolle für alles Leben auf der Erde spielen, ist es wichtig, bereits in jungen Jahren darüber zu lernen. Um Lernschwierigkeiten zu vermeiden, ist es wichtig, Vorstellungen von Kindern zu biologischen Themen zu kennen und einzubeziehen. Diese Arbeit untersucht ihre Sicht auf den Lebenszyklus von Blütenpflanzen, da dazu wenige Studien existieren.

16 Kinder im Alter von 5–6 Jahren aus einem Wiener Kindergarten nahmen dabei an einer Pre-, Post-, Late-Post-Studie teil. Die Vorstellungen der Kinder zum Lebens- & Reproduktionszyklus von Pflanzen wurden dabei in Form von Zeichnungen und Gruppeninterviews erhoben. Durch eine 4-tägige Intervention, die auf den Ergebnissen der Pre-Interviews basierte, wurde versucht, das Lernen hin zu wissenschaftlichen Vorstellungen zu unterstützen.

Die Konzepte der Kinder sind eine Mischung aus alternativen und wissenschaftlichen Vorstellungen zu allen Stadien des Lebenszyklus, die sich durch die Intervention teilweise weiterentwickeln konnten. Die Kinder hatten von Anfang an ein Verständnis darüber, dass Pflanzen aus Samen wachsen und Wasser und Licht brauchen. Durch die Intervention konnten später die meisten Kinder den Zusammenhang zwischen Blüte und Frucht beschreiben. Es zeigte sich eine Reihe anthropomorpher und anthropozentrischer Denkweisen, die vor allem in Bezug auf die Ausbreitung von Samen ab den Post-Interviews in den Hintergrund trat. Ab den Post-Interviews wussten manche Kinder um die Existenz von Pollen, den Prozess der Bestäubung konnten sie aber zu keinem Zeitpunkt erklären.

Das Interesse der Kinder konnte durch den Einsatz lebender Pflanzen in unterschiedlichen Zyklusphasen, verschiedene Sinneserfahrungen und die Untersuchung von Pflanzen unter Auflichtmikroskopen am meisten geweckt werden.

Keywords: intuitive concepts, naive concepts, everyday ideas, design-based research, life cycle of plants, children aged 5–6.

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Introduction and Theoretical Background

Plants play a central role in ecosystems and human nutrition, yet the interest of students and teachers in plants is often low and is further tied only to various contexts (Hammann et al. 2020), as it is the case in useful plants (ibid.; Pany 2014). Low interest is reflected in the rather rudimentary biological understanding that even secondary school students have regarding the life cycle of flowering plants (Lampert et al. 2019, 2020; Quinte et al. 2012). Young children also pay little attention to plants. But due to their intrinsic motivation when encountering natural phenomena, there is an opportunity for them to develop an understanding of plants at an early age if adults direct their attention toward them (Gatt et al. 2007; Lück, 2018). Lindemann-Matthies (2005) showed this in Switzerland with primary school students and plants recognized along their way to school.

In the early years of life, including kindergarten, children acquire a substantial amount of new knowledge and gain experiences that are interconnected and related (Lohaus & Vierhaus, 2013). They develop ideas – personal cognitive processes about the world (Kattmann 2016) – that are grouped into categories. The mental constructs that describe the characteristics, as well as the similarities and differences among members of a category, are called concepts (Lohaus & Vierhaus 2013).

When the knowledge acquired thus far is insufficient to explain natural phenomena, children form their ideas and concepts. These often contradict scientific findings, in which case they are referred to as intuitive ideas and concepts (Renkl 2000; Lohaus & Vierhaus 2013). Such ideas develop from early childhood over an extended period, becoming deeply ingrained and cannot easily be replaced in school by scientifically accurate concepts (Göhring 2010). It is therefore important to understand the learners' preconceptions and build upon them (Feige et al. 2017) to take their learning prerequisites into account. Above all, it is crucial to promote the learners' active engagement in constructing knowledge (Göhring 2010; Lück 2018), which often cannot be achieved by the usual explanations provided in class (Möller 2013).

Sensory experiences and scientific experiments are highly effective when working with kindergarten children. They are accompanied by age-appropriate didactic reduction in simple language. The interpretation of experiments with kindergarten children can take two forms: through analogies – vivid comparisons of the natural phenomenon with the children's world – and through animism, which in a didactic context refers to a deliberate imbuing of both lifeless and living nature with spirit. Animism, or anthropomorphism – that is, the attribution of human characteristics or behaviours – is also a natural part of child development (Piaget 2010; Lück 2018; Gebhard 2020) and can be used for learning.

Studies on kindergarten children's ideas have shown different aspects of their understanding of plants. Gatt et al. (2007) described concepts of children aged 4–5 in Malta, based on the plants they could name and their explanations of categorizing images as plants. Based on the interviews it became clear that when children think of plants, they primarily imagine something small and green with a stem and leaves. For many of the children, one attribute like colour or size was enough to categorise a picture shown to them as a plant. What didn't fit that concept and often was not considered a plant, for example, were a cactus with thorns or a flower.

Anderson et al. (2014) investigated how children aged 5 to 6 in the USA imagine the appearance of plants and what they believe plants need to grow. The most frequently depicted feature in the children´s drawings was the stem; however, in most cases, the stem lacked leaves – unlike in the findings of Gatt et al. (2007). Only a few children included roots in their drawings. When asked, they explained that roots are not visible because they are underground, or they simply forgot what is beneath the surface. A recent study with children/youth from 6 to 18 years (Pany et al. 2025) found that roots are drawn only by older kids and youth. While most children understood that roots are involved in water uptake, they were generally unable to explain how this process works. Regarding growth requirements, way more children included sunlight than soil (Gatt et al. 2007).

In a study conducted in England, Jewell (2002) asked children aged 4–5, 7–8, and 10–11 to sort various items into "seeds" and "non-seeds." The results showed that some seeds were not classified as such because they were edible. Size and shape also posed challenges for classification, as seen with walnuts, maple seeds, and pine seeds. Jewell (2002) also asked about the conditions required for seed germination. The most frequently mentioned factor was water, and many children also named the sun or light. Only children aged seven and older often mentioned soil as well.

Explaining seed formation proved difficult, especially for the 4–5-year-olds. Their ideas included notions such as seeds growing together with the apple, the apple producing the seed, or another tree being involved – e.g., one tree giving the seed to another.

Children sometimes also believe that seeds are produced by humans (Piaget 1929 S. 334ff).

In a study by Hickling and Gelman (1995) conducted in the United States with 4- to 5-year-old children, it was found that younger children, particularly those at the beginning of their fourth year, more often viewed the life of plants as linear – ending with a specific stage, such as the fully grown tree. As age increased, children increasingly understood the life of plants as a cycle that continues with the formation of new seeds.

Research Interest

This work examines the ideas and concepts of children aged 5–6 years regarding the cycle of flowering plants and all the essential stages and processes it entails. These aspects have not yet been explored in detail within this age group. Based on the literature, the following research questions were derived:

What concepts and ideas do 5–6-year-old children have about seeds, the germination of seeds, plant growth and its conditions, the formation of fruits and seeds, and the dispersal of seeds? How can an intervention change these ideas? Do these changes of ideas last over a period of 7.5 weeks?

Methods

The research framework was based on the Design-Based Research approach (Altrichter 2018; Scott et al. 2020), which links subject-specific didactic research with practical solutions in education and tests them in practice. The study was conducted from March 2024 to June 2024 in a kindergarten located in the 23rd district of Vienna, Austria with 16 children from five different kindergarten groups.

Fig. 1 provides an overview of the research process. All interviews were conducted in groups of 3–5 children. A guideline for semi-structured interviews was developed for each interview phase. At the beginning, children's ideas were gathered through pre-interviews (n=4). Based on previous studies, recommendations from experts, the collected preconceptions, and the experiences of the first author as a kindergarten educator, the intervention was designed. This intervention was carried out over one and a half weeks, comprising four sequential experimental sessions with all the children, divided into two groups (about 30 minutes for each group and session).

The sessions included an experiment on the germination conditions of garden cress, several plants from the life cycle of sugar snap peas, and two strawberry plants in their flowering and fruiting stages, which were observed and discussed throughout the period. Additional methods involved organizing a dandelion life cycle using living plants, examining seedlings and flowers with cup magnifiers and microscopes, observing ornamental houseplants

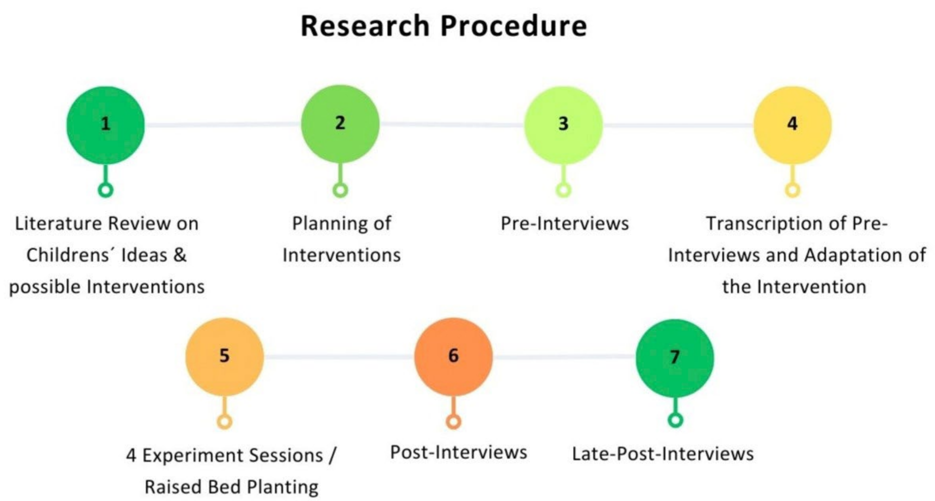

Fig. 1: Research Procedure | **Abb. 1:** Forschungsablauf

grown in different substrates, tasting salt and sugar with a subsequent discussion of mineral salts in soil and fertilizer as well as plant-based sugar production, and tasting fruits while searching them for seeds. Coincidentally, during the same period, a raised-bed planting took place at the kindergarten with the same children, in which regional vegetables, fruits, and herbs were sown and planted – a factor that most likely also influenced the children's learning.

In post-interviews (n=3) conducted five days after the intervention and late-post-interviews (n=3) conducted 7.5 weeks later, the effects and long-term impact of the intervention were examined. All interviews were recorded as audio files, transcribed, the names of the children anonymized, and the text edited and redacted. Additionally, the children created drawings (n=38) as part of all interviews. The interviews and the drawings included questions and tasks related to the different stages and processes in the life cycle of plants, from seeds to the dispersal of new seeds. The experimental sessions were also recorded, and partial transcripts were created for passages that seemed relevant for assessing the outcomes and methods of the intervention.

During the analysis of the results, different categorization approaches were possible depending on the research question. The most suitable method was chosen in each case. For each interview phase, differentiation was made within the interview groups (counting per interview). Due to organizational constraints, it was not possible to keep the same children in consistent groups. Therefore, no comparisons were made between interview groups on different days; instead, a general comparison was conducted between pre-, post-, and late-post-interviews (counting per interview phase). When analysing the drawings, either each drawing or each child was considered separately – some children created multiple drawings in which elements were repeated. For the formation of concepts, all statements supporting a specific concept were counted, regardless of the interview group.

Findings

The results are presented in the logic of the life cycle of plants, and the pre-, post-, and late-post-interviews are compared to display the conceptual development.

Findings about seeds

As shown in Tab. 1, the terms *"seeds"* (German: Samen) and *"pips"* (German: Kerne) were used most frequently and consistently across all interview phases. However, in the pre-interviews, the term *"seeds"* was only partially used by the children until it was introduced by the interviewer. Starting from the post-interviews on, the term *"seeds"* was actively used in all interview groups. In the post-interviews, compound words including *"pips"* emerged, such as *"apple pips"* (German: Apfelkerne) *"pea pips" (German: Erbsenkerne)*, and *"sunflower pips"* (German: Sonnenblumenkerne). By the late-post-interviews, the use of *"pips"* had become less frequent, and compound nouns (in German very common) were replaced by terms incorporating *"seed,"* such as *"apple seed"* and *"sunflower seed."*

During the study, eight different concepts regarding seeds were identified. The most significant concept appeared to be *"plants grow from seeds."* This was confirmed by ten statements

Tab. 1: Key findings about seeds | **Tab. 1:** Wichtige Ergebnisse über Samen

Category	Pre-Interviews	Post-Interviews	Late-Post-Interviews
Most used terms for seeds	Seeds (German: Samen), grains (German: Körner), pips (German: Kerne), apple pips (German: Apfelkerne)	seeds	seeds, pips
Other terms used for seeds	apple grains (German: Apfelkörner), seed grains (German: Samenkörner), stones (German: Steine), things (German: Sachen), marbles (German: Kugeln)	pips, compound words with "pips": apple pips, pee pips, sunflower pips	compound words with "seed", also apple seed, new: diminutive of kernels (German: Kernchen)
Concepts about seeds	Plants grow from seeds (n=9)	Plants grow from seeds (n=1)	Plants grow from seeds is no longer explicitly mentioned, but all explanations indicate that the concept is understood
	There are edible and non-edible seeds (n=4)	Seeds are not edible (n=1)	There are edible and non-edible seeds (n=1)
	Fruits grow from seeds (n=3)	Nuts are not seeds (n=1)	Seeds have a specific shape but different sizes (n=1)
	The seed belongs in the fruit (n=1)		
	The seed germinates in the fruit (n=1)		

in the interviews. However, all verbal responses and drawings from the children after the post-interviews indicate that this concept was firmly understood by all participants. This is further supported by the fact that the contradictory concept found in the pre-interviews – *"fruits grow from seeds"* – was no longer present after the post-interviews. Similarly, the concepts *"the seed belongs in the fruit"* and *"the seed germinates in the fruit"* only appeared in the pre-interviews.

The edibility of seeds was discussed on each interview phase. In the pre-interviews, specific seeds were mentioned as either edible or non-edible. However, in the post-interviews, one child (Cora) expressed the concept that seeds were generally not edible, leading to the concept *"nuts (which are edible) are not seeds."* In the latepost-interviews, nuts were no longer discussed, but the edibility of seeds still confused Cora.

Findings about germination

At the beginning of the intervention, the term *"to germinate"* was used and explained several times by the interviewer. The children used the term only in the post-interviews, but they were unable to apply it correctly in a technical sense (Tab.2). Two children even regarded *"to germinate"* as a synonym for plant growth.

Tab. 2: Key findings about germination | **Tab. 2:** Wichtige Ergebnisse über Keimung

Category	Pre Interviews	Post Interviews	Late Post Interviews
Ideas about germination	Something cracks open	The first to come out of the seed coat:	The first to come out of the seed coat:
	The seed grows into the soil	Root (n=3)	Root (n=2)
		Leaf (n=2)	Head (n=1)
		Stem (n=1)	Stem (n=1)
			Plant (n=1)
Meaning of the term "to germinate"	Blooming? Blossoming?	A synonym for plant growth	term wasn't mentioned by the children
	Root	Something the seed needs to begin growing	
		Something that must happen to the flowers for fruits to grow from them	
Mentioned conditions of germination	no questions during the interviews	1st answer in all groups: water (n=3)	1st answer in all groups: water (n=3)
		Light (n=1)	Light (n=2)
		Seed (n=1)	Seed (n=1)
			Earth (n=1)
			"Without light, it didn't work because they turn yellow."
Drawings of roots	1	7	2

Regarding germination, the children described in the pre-interviews that something would crack open first (Tab.2), presumably the seed, and that the seed would grow on the ground. From the post-interviews onward, they were asked what emerges first from the seed coat. At all interview phases, intuitive ideas were expressed. The colloquial term *"flower"* was mentioned in the pre-interviews, along with plant organs such as *"stem"* (in the post- and late-post-interviews) and *"leaf"*, as well as *"head"* (in the late-post-interviews), reflecting the children's tendency to draw analogies to humans or animals (Gebhard 2020). Additionally, they also mentioned *"plant"* (in the late-post-interviews) or *"mini-plant"* (in the pre-interviews). In the post- and late-post-interviews, several children correctly answered the question by stating *"root"*. In the post-interviews, significantly more children (n=7) depicted the drawn plants with *"roots"* (Tab.2, Fig.2) compared to the pre-interviews (n=1) and late-post-interviews (n=2). In Figure 2, the seeds of two plants can also be seen between the roots and the shoot axis. These were drawn first as part of the drawing task, followed by what grows next from the plant, according to the children.

Fig. 2: Part of a drawing from post interviews - trees with significant roots and a visible seed | **Abb. 2:** Ausschnitt einer Zeichnung der Post-Interviews – Baum mit auffälligen Wurzeln und sichtbarem Samen

After the pre-interviews, in which no distinction was made between germination and growth conditions (Tab.2), an experiment was conducted on this topic. Water as a germination condition was mentioned first in all post- and late-post-interviews and was clear to all children – with one exception in the late-post-interviews. However, the children did not agree in either the post- or late-post-interviews on whether plants need light for germination, even though the intervention experiment demonstrated that at least garden cress does not require light for germination. In the late-post-interviews, soil and seeds were mentioned as germination conditions.

Findings about plant growth

The drawing task incorporated the various growth stages of plants. Almost all children immediately drew a fully grown tree after drawing the seed. Across all interviews, 18 ideas

Tab. 3: Key findings about plant growth | **Tab. 3:** Wichtige Ergebnisse über Pflanzenwachstum

Category	Pre Interviews	Post Interviews	Late Post Interviews
Ideas about plant growth	3 different ideas	7 different ideas, e.g.:	10 different ideas, e.g.:
	Plant growth as a cycle (n=4)	Leaves grow after the stem (n=1)	Fruits grow from the flower (n=2)
	Plant growth as linear (n=1)	Flowers grow before the fruits (n=1)	Flowers grow before the fruits (n=1)
	Fruits and plants keep growing larger (n=2)	Buds grow before the fruits (n=1)	The seed comes before the fruits (n=1)
Mentioned growth conditions	Water (n=4)	Water (n=3)	not mentioned
	Sun (n=4)	Sun (n=2)	
	Earth (n=1)	Plenty of space (n=1)	
	Flowers (n=1)		
Ideas why plants need water	no questions during the interviews	to grow	not mentioned
Ideas why plants need light	no questions during the interviews	to grow further	For growing, to avoid turning yellow
Ideas why plants need soil	no questions during the interviews	To grow, hold on, and stand	For getting bigger, holding on, and growing

and concepts regarding plant growth were recorded, with three of them appearing at two interview phases: *"Before the fruits, flowers grow"*, *"After the shoot axis, leaves grow"*, and *"Plant growth as a cycle"*. The latter was mostly supported by statements in the pre-interviews; however, no later statements contradicted this concept, nor were there any questions referring to it. Only one statement in the pre-interviews indicated a linear view of a plant's life cycle, suggesting that the seeds from apples cannot be used to grow new trees, but rather, *"fresh"* ones are needed.

Additional ideas primarily described which part of the plant grows in which order largely corresponded to reality. Depending on the plant and the child, the drawings and their labels revealed a mix of intuitive and scientific ideas about plant growth forms. Most frequently, apple and cherry trees were drawn; however, there was also a noticeably different drawing of an *"apple plant"* alongside an *"apple tree"*, a *"chestnut tree"*, *"flower trees"*, *"sugar snap pea trees"*, a *"strawberry tree"*, and a *"strawberry bush"*. Garden cress was rarely drawn and was referred to as *"cress"*, *"cress stems"*, and *"cress plant"*. The greatest variety of plants and concepts was evident in the drawings from the post-interviews. In the late-post-interviews, there were few variations in the drawings, and none of them reflected an intuitive idea anymore.

In the pre-interviews, children were asked what helps plants to grow. In all groups, water and sun were mentioned. In one group, soil and flowers were also mentioned. From the post-interviews onward, children were asked why plants need water, light, and soil. Most of the explanations in the post- and late-post-interviews referred to growing or getting bigger – or, in one instance (late-post), to preventing the plants from turning yellow, which was an effect of the intervention and the observations made there (this is an example of an experiment, which is interpreted in an everyday worldview). When the focus shifted to the roots of the plants, children in all post-interview groups explained that plants need soil to hold on to or to prevent them from swaying or being blown away in a storm. This explanation was also provided in all the late-post-interviews, although in two out of three groups, there was no longer any mention of the roots. In two out of three post-interview groups, water uptake through the roots was mentioned, but not in the late-post-interviews.

In the late-post-interviews, two children explained that plants extract what they need from water or, with the roots, from the soil. This could be a reference to the mineral salts in the soil or fertilizer discussed during the experimental sessions.

Findings about pollination and fruit formation

Pollen and pollination were not mentioned by the children in the pre-interviews, as shown in Tab. 4, and only one child described flowers, bees, and nectar in connection with the plant life cycle, even drawing flowers on the apple tree (Fig. 3). Regarding the origin of seeds, four concepts emerged: *"Seeds come from fruits"* (n=6), *"Seeds come from trees"* (n=1), *"Seeds come from different species"* (n=1) – noting that *"species"* was used in everyday language rather than as a biological term – and *"Seeds are produced"*, which presumably referred to human production (cf. Piaget 1929).

Fig. 3: Part of a drawing from pre-interviews – apple tree with flowers | **Abb. 3:** Ausschnitt einer Zeichnung der Pre-Interviews – Apfelbaum mit Blüten

The experimental sessions aimed to raise awareness of pollen, pollination, and the connection between flower and fruit, and from the post-interviews onward, these topics were addressed directly. An understanding of pollination was still lacking after the intervention, although with assistance by the interviewer in the post- and late-post-interviews, the terms pollen and "Blütenstaub" (a compound noun in German everyday language used for pollen, translates directly as *"blossom dust")* – were sometimes mentioned[1]. As flower visitors, bees were predominantly named, with caterpillars mentioned on one occasion. Concerning flower visits, almost exclusively, nectar, honey, or honey production was brought up. Several intuitive ideas emerged, such as *"(On the flower) they (the bees) suck in the honey"* (Karina, Post-Interview 3) and *"Then it (the bee) takes the pollen and makes honey out of it for humans"* (Lisa, Late-Post-Interview 2). One statement from the late-post-interviews described that the bees fly away from the flower and leave something behind, which was the closest description of pollination provided.

1 See Lampert et al. (2018) for a discussion of this German term concerning learning the reproduction of plants.

Tab. 4: Key findings about pollination and fruit formation | **Tab. 4:** Wichtige Ergebnisse über Bestäubung und Fruchtbildung

Category	Pre Interviews	Post Interviews	Late Post Interviews
Ideas about pollination and flowers	Pollination not mentioned	Mention of pollen, nectar, and bees	Mention of pollen, nectar
	Mention of nectar and bees	Pollination not understood	Intuitive concepts about flower visits and bees
	Flowers help plants grow	More awareness of nectar than pollen	Caterpillar as a flower visitor
			Pollination not understood
			Bees leave something on the flowers
Ideas about the origin of seeds	Seeds come from fruits (n=6)	no mentions during the interviews	no mentions during the interviews
	Seeds come from trees (n=1)		
	Seeds come from different species (n=1)		
	Seeds are produced (n=1)		
Ideas about the connection between flowers and fruit	no mentions during the interviews	Flowers must grow before the fruits	Flowers must grow before the fruits
		The fruit grows from the flower	The fruit grows: from the flower, on the branches, at the top

In both the post- and late-post-interviews, it was explained in each group that *"a flower must grow before the fruits"*, and some children also described that the fruit grows exactly where the flower has been, although there were uncertainties among other children regarding the precise location of fruit growth. One child understood for the first time during a late-post-interview that an apple can grow from every apple blossom pointing to a picture and asking, *"And there, and there and there and there too?"* (Victor, Late-Post-Interview 1).

Findings about seed dispersal

Regarding seed dispersal, a total of eight concepts were identified throughout the study, of which three were described at all interview phases: *"Dispersal by humans"*, *"Dispersal by animals"*, and *"Dispersal by wind"*. It was noticeable that in the pre-interviews, *"Dispersal by humans"* was always mentioned first and was the most frequently cited (n=5), while in the post-interviews it was mentioned after other forms of seed dispersal in all groups, and

Tab. 5: Key findings about seed dispersal | **Tab. 5:** Wichtige Ergebnisse über Samenausbreitung

Category	Pre Interviews	Post Interviews	Late Post Interviews
Concepts about seed dispersal	Dispersal by humans (n=5, always mentioned first)	Dispersal by humans (n=3, never mentioned first)	Dispersal by humans (n=3)
	Dispersal by wind (n=2)	Dispersal by wind (n=2)	Dispersal by wind (n=3)
	Dispersal by animals (n=1)	Dispersal by animals (n=3)	Dispersal by animals (n=6)
	Dispersal by rain (n=1)		Dispersal by rain (n=1)
	Self-dispersal (n=1)		Dispersal by gravity (n=1)
	No plants grow without humans (n=1)		Dispersal by hail (n=1)
Dispersal by animals	Many intuitive ideas including fantasy stories		

its frequency decreased (n=3). *"Dispersal by wind"* remained relatively consistent with 2 mentions in the pre-interviews and 3 in the late-post-interviews, and it rarely referred to typically wind-dispersed species. Explanations regarding *"Dispersal by animals"* increased markedly, with one mention in the pre-interviews, three in the post-interviews, and six in the late-post-interviews. The children expressed a variety of intuitive ideas related to their perceptions of animal behaviour; for example, that worms carry and bury the apple seed in the soil. One child recalled the seed dispersal through animal droppings – which was discussed during the experimental sessions – up to the late-post-interviews. Other ideas included seeds dispersing on their own (pre-interviews) and that no new plants can grow without humans (pre-interviews), as well as *"Dispersal by rain"* (pre- and late-post-interviews), *"Dispersal by gravity"* (late-post-interviews), and *"Dispersal by hail"* (late-post-interviews).

Discussion

General Comments on the Findings

The results of this study show that children aged 5 to 6 exhibit a mix of intuitive and scientific ideas regarding the different stages of the plant life cycle. From this study, no uniform pattern can be described regarding the increase in knowledge and the changes in ideas from the pre-, to post-, and late-post-interviews. Some topics showed an increase in knowledge and ideas in the post-interviews that could not be confirmed in the late-post-interviews (e.g., drawings of *"roots"*, plant growth forms, and the use of the term *"to germinate"*). For other concepts, an increase in knowledge was even observed in the late-post-interview (seed dispersal by animals). Overall, the children developed a more extensive understanding of the plant life cycle. The evolution of the drawings as well as the differences in the interviews demonstrate that the changes in understanding and ideas depended on the specific topics (e.g., germination, pollination, seed dispersal) and methods of the various interventions.

Answering the Research Questions & Comparison with Other Studies

Throughout the study, all children clearly understood that plants grow from seeds. The few intuitive concepts still present in the pre-interviews disappeared after the experiments. Also of interest were the children's ideas about the edibility of seeds. Most of them distinguished between edible and non-edible seeds. However, one child expressed the idea that seeds are not edible at all, leading them to exclude nuts and chestnuts from the category of seeds. Similar difficulties in classifying edible seeds were also reported in the study by Jewell (2002).

Even before the intervention, two ideas about what happens during germination were mentioned in the pre-interviews: that something would crack open first and that the seed would grow on the ground. In the post- and late-post-interviews, children were specifically asked about germination: *"What emerges first from the seed coat?"* Here, intuitive answers such as "stem," "leaf," and "head" were given. However, several children correctly answered "root." These answers, along with the fact that children drew roots significantly more often in the post-interviews than on the other interview phases, indicate that the intervention had an effect in this area. Pany et al. (2025) showed in their study with drawings that the amount of drawn roots significantly increases in the age of 12 to 13. In contrast, the children were not able to correctly use or explain the term "to germinate." The interviews suggest that the use and explanation of the term may have hindered their understanding.

From the post-interviews onward, all children – with one exception – knew that plants need water to germinate. It remains unclear whether they already had this knowledge before the intervention or whether they acquired it through the process, as germination conditions were only explicitly addressed from the post-interviews onward. What is certain is that the experiment on cress seed germination led to disagreement among the children regarding whether garden cress needs light to germinate. The experiment may also have helped clarify that seeds don't need soil to germinate, since soil as a condition for germination was only mentioned once by one child in the (late-post-interviews). Interestingly, two children named seeds themselves as a condition for germination.

The drawing tasks revealed that before the intervention, the children had very limited ideas about plant growth. They were barely able to illustrate individual stages of growth. From the post-interviews onward, various verbal expressions emerged about the order in which plant parts grow. Most of these ideas were consistent with actual plant growth, such as *"Before the fruits, flowers grow."*

The study also revealed different ideas about which plants grow as herbs, shrubs, or trees, showing again a mixture of intuitive and scientific understanding.

On the other hand, an awareness of the cyclical life cycle of plants was demonstrated on multiple occasions. This stands in contrast to other studies with kindergarten children (Hickling & Gelman 1995, p. 870) and with older students (Quinte et al. 2012, p. 44). In this research, there was only one indication that children had a linear view of plant life – a view that did not recur after the pre-interviews. In contrast, several statements at two interview phases (pre- and late-post-interviews) confirmed a cyclical understanding in which new plants grow from the seeds. However, describing or drawing the entire cycle with all its essential stages and processes proved challenging for all children, and individual stages were frequently omitted or confused (Lampert et al. 2019; 2020).

As in a study by Anderson et al. (2014), the children were aware that plants need water and sunlight to grow. Soil and flowers were also mentioned, though less frequently, in the pre-interviews. After the intervention, explanations for why plants need water and light remained superficial, with answers typically referring to growing bigger. However, one child remembered that plants turn yellow without light. Also, the discussion of plant sugar production and the uptake of mineral salts from the soil (i.e., physiological processes) showed no discernible effect and may, therefore, still be too challenging for kindergarten children in general or may need much more experience and effort to lay foundations. However, the children provided concrete explanations regarding the importance of soil for plant growth: for anchoring in the ground and – only in the post-interviews – for water absorption. These aspects were understood.

The children showed the greatest difficulties in understanding pollination. While the intervention slightly raised awareness of the existence of pollen, no child could describe the process of pollination anything approaching scientific accuracy. Flower visits were mostly associated with nectar and honey, but rarely with pollen. Several intuitive ideas also emerged around flower visits and honey production.However, the intervention did help many children understand the connection between flowers and fruits.

Throughout the study, the children consistently knew that seeds can be dispersed in various ways – by humans, animals, or wind. The intervention shifted the children´s focus away from seed dispersal by humans, which had dominated in the pre-interviews. Dispersal by animals became increasingly important to the children with each interview phase. However, intuitive ideas prevailed in this area, especially those relating to animal behaviour.

Children of this age tend to explain phenomena with anthropomorphism and anthropocentrism (Gebhard 2020), using analogies related to living beings as well as objects. Examples include descriptions of human and animal parts or activities that were transferred to plants (*"head," "thirst," "to drink water down"*) or to objects (*"top part," "front part"*), which can be challenging to interpret given the distinct nature of plants. Two explanations regarding how plants take up water also showed a clear distinction between humans and plants: *"They (plants) can't drink every day like we humans do"* (Lisa, Late-Post-Interview 2) and *"It (the plant) doesn't drink it, the water just goes into the soil. It takes it in into its body. With the roots"* (Victor, Late-Post-Interview 1).

In many topics, a pronounced anthropocentrism was evident – for instance, in the statement that bees produce honey for humans, which is a classical and widespread anthropocentric view of the role of bees among people without considering plant reproduction (Lampert et al. 2019; 2020). Other statements were that plants cannot grow without humans or that seeds are produced by humans. Through the interventions, however, this anthropocentric thinking was mitigated, for example, concerning seed dispersal.

Limitations of the Study

Although the study provides many interesting insights into kindergarten children's ideas, it also has its limitations. Comparisons between pre-post and late-post interviews were only partially possible because some interview questions were modified after the pre-interviews. As a result, the effects of the intervention can only be assessed to a certain extent. The study was also conducted in a single kindergarten with a small number of participants. Because the entire plant life cycle was addressed, some topics could not be explored in depth – neither during the intervention nor in the interviews.

For similar studies, it may be advisable to focus on a single phase and examine it in greater depth. Providing an overview of all stages can still be a useful supplement. Pollination and seed dispersal by animals require further exploration and the development of more effective methods.

Implications for kindergarten education

When learning about plants, real-life encounters should be used instead of pictures. This includes different stages of the life cycle, for example, while gardening with the children, as well as examining displayed ornamental houseplants, and different parts of plants such as blossoms, fruits, and seeds.

When learning about pollination, the pollen should be visualised first, for example with a microscope. Then, observing bees visiting flowers and discussing what happens could be the next step. Using flower models, like those of Hämmerle et al. (2024), can help creating first-hand experience from the perspective of a visiting insect. Learning about animal behaviour is necessary when teaching seed dispersal, as well as observations and experiments in nature (for example, regarding wind-dispersed seeds and the slingshot mechanism of balsam plant or touch-me-not (*Impatiens spp.).* To show the progression from blooming to fruit formation, time-lapse videos or photo series could be beneficial. Verbal explanations and the amount of questions and puzzles used should be kept short – a point the children themselves noted during this intervention. Also, educational settings should always include sensory experiences and experiments. In this study, the children especially enjoyed tasting the fruits and exploring parts of the plant with cup magnifiers and microscopes.

Literature

Altrichter H (2018) Aktionsforschung und Design-Based Development. In: Posch P, Rauch F, Zehetmeier S (Eds.) Das Lernen von Lehrerinnen und Lehrern, Organisationen und Systemen. Waxmann Verlag GmbH 135–148 (ISBN 978-3-8309-3842-2)

Anderson JL, Ellis JP, Jones AM (2014) Understanding Early Elementary Children's Conceptual Knowledge of Plant Structure and Function through Drawings. CBE – Life Sciences Education 13(3), 375–386 (https://doi.org/10.1187/cbe.13-12-0230)

Feige E-M, Rutsch J, Dörfler T, Rehm M (2017) Von der Alltagsvorstellung zum fachwissenschaftlichen Konzept. Schülervorstellungen diagnostizieren und weiterentwickeln. Unterricht Chemie 159, 2–8

Gatt S, Tunnicliffe SD, Borg K, Lautier K (2007) Young Maltese children's ideas about plants. Journal of Biological Education 41(3), 117–122 (https://doi.org/10.1080/00219266.2007.9656080)

Gebhard U (2020) Kind und Natur: Die Bedeutung der Natur für die psychische Entwicklung (5., aktualisierte Auflage). Springer VS

Göhring A (2010) Selbstbestimmtes Lernen im naturwissenschaftlichen Unterricht: Eine empirische Interventionsstudie. Kovač, 334 pp. (ISBN 9783830048527)

Hammann M, Jördens J, Büschgens D (2020) Students' situational interest in cultivated plants: The importance of contextualisation and topic selection. International Journal of Science Education 42(16), 2765–2799 (https://doi.org/10.1080/09500693.2020.1836430)

Hämmerle L, Hlavka D, Kiehn M, Pany P, Lampert P (2024) Interacting with Legumes – Teaching About Pollination and Adaptations Using Functional Flower Models of Fabaceae. The American Biology Teacher 86(4), 205–212 (https://doi.org/10.1525/abt.2024.86.4.205)

Hickling AK, Gelman SA (1995) How Does Your Garden Grow? Early Conceptualization of Seeds and Their Place in the Plant Growth Cycle. Child Development 66(3), 856–876 (https://doi.org/10.2307/1131955)

Kattmann U (2016) Schüler besser verstehen: Alltagsvorstellungen im Biologieunterricht. Aulis, Hallbergmoos 428 pp. (ISBN 9783761429419)

Lampert P, Müllner B, Pany P, Scheuch M, Kiehn M (2020) Students' conceptions of plant reproduction processes. Journal of Biological Education 54(2), 213–223 (https://doi.org/10.1080/00219266.2020.1739424)

Lampert P, Scheuch M, Kiehn M (2018) Wie pflanzen sich Pflanzen fort? – Eine fachliche Klärung. Erkenntnisweg Biologiedidaktik, 17, 9–25

Lampert P, Scheuch M, Pany P, Müllner B, Kiehn M (2019) Understanding students' conceptions of plant reproduction to better teach plant biology in schools. PLANTS, PEOPLE, PLANET 1(3), 248–260 (https://doi.org/10.1002/ppp3.52)

Lindemann-Matthies P (2005) 'Loveable' mammals and 'lifeless' plants: How children's interest in common local organisms can be enhanced through observation of nature. International Journal of Science Education 27(6), 655–677 (https://doi.org/10.1080/09500690500038116)

Lohaus A, Vierhaus M (2013) Entwicklungspsychologie des Kindes- und Jugendalters für Bachelor: Lesen, Hören, Lernen im Web (2., überarbeitete Auflage). Springer, Berlin Heidelberg 298 pp. (ISBN 9783642344343)

Lück G (2018) Handbuch der naturwissenschaftlichen Bildung: Theorie und Praxis für die Arbeit in Kindertageseinrichtungen. Herder, Freiburg Basel Wien 240 pp. (ISBN 3-451-37936-8)

Möller K (2013) Lernen von Naturwissenschaften heisst: Konzepte verändern. In: Labudde P (Hrsg.), Fachdidaktik Naturwissenschaft: 1.- 9. Schuljahr (2., korrigierte Auflage). Haupt Verlag, Bern, 57–72 (ISBN 9783825240479)

Pany P (2014) Students' interest in useful plants: A potential key to counteract plant blindness. Plant Science Bulletin 60(1), 18–27

Pany P, Dünser B, Eichler M, & Lampert P (2025) Students' mental models of plants – an analysis of plant drawings across age groups. Journal of Biological Education, (https://doi.org/10.1080/00219266.2025.2533780)

Piaget J (1929) The child's conception of the world. Routledge & Kegan Paul LTD 379 pp.

Piaget J (2010) Das Weltbild des Kindes (Ungekürzte Ausg., 9. Aufl). Dt. Taschenbuch-Verl, München 245 pp. (ISBN 3-423-35004-0)

Quinte J, Lindemann-Matthies P, Lehnert H-J (2012) Denkmodelle vom Lebenszyklus der Samenpflanzen. Erkenntnisweg Biologiedidaktik 11, 37–52

Renkl A (2000) Intuitive Konzepte. Lexikon der Psychologie. https://www.spektrum.de/lexikon/psychologie/intuitive-konzepte/7433

Scott EE, Wenderoth MP, Doherty JH (2020) Design-Based Research: A Methodology to Extend and Enrich Biology Education Research. CBE – Life Sciences Education 19(3), es11 (https://doi.org/10.1187/cbe.19-11-0245)