education sciences

Article

Play-Based Physics Learning in Kindergarten

Nathalie Glauser-Abou Ismail [1], Angelika Pahl [2,*] and Reinhard Tschiesner [3]

[1] Institute for Further Education, University of Teacher Education Bern, 3012 Bern, Switzerland; nathalie.glauser@phbern.ch
[2] Institue for Primary Education, University of Teacher Education Bern, 3012 Bern, Switzerland
[3] Faculty of Education, Free University of Bozen-Bolzano, 39042 Brixen, Italy; reinhard.tschiesner@unibz.it
* Correspondence: angelika.pahl@phbern.ch

Abstract: This article highlights the importance of play as a learning approach in early physics education. It demonstrates the concept of an innovative didactic method that combines children's free play with physics learning in kindergarten. This play-based learning approach enables children to experience and recognize physical laws in a self-directed, action-oriented, and playful manner. The article provides concrete insights into how kindergarten teachers can stimulate physics-related learning moments, starting from free-play situations. Moreover, it points out the teacher's crucial role in creating suitable play environments, providing feedback in play, and facilitating shared thinking after play. The article is based on the didactic development project "je-desto", which aims to promote play-based science learning in kindergarten by familiarizing kindergarten teachers with this promising didactic approach. Accordingly, this article provides kindergarten teachers and experts in subject didactics an answer to what play-based physics learning can look in practice.

Keywords: play-based learning; science education; play; children; kindergarten; teacher

Citation: Glauser-Abou Ismail, N.; Pahl, A.; Tschiesner, R. Play-Based Physics Learning in Kindergarten. *Educ. Sci.* **2022**, *12*, 300. https://doi.org/10.3390/educsci12050300

Academic Editor: Kristiina Kumpulainen

Received: 28 February 2022
Accepted: 19 April 2022
Published: 23 April 2022

1. Introduction

When children play, they learn [1]. This statement is clearly expressed in the new Swiss curriculum for kindergarten and primary schools, and highlights that playing and learning are not opposing activities, as is often assumed in everyday life [2,3]. Playful learning approaches combine free play with guided play, and enable children's joyful, self-directed activities as well as the acquisition of knowledge and competences [1,2,4,5]. The importance of play as an effective learning opportunity—even for subject-related competences—is often still unrecognized in kindergarten practice. Early education programs usually take the form of guided sequences or direct instruction [2,6,7]. In comparison to directed instruction, however, play-based learning has been proven to be more effective for the learning of young children [8–11]. This finding was also evidenced for natural science learning in kindergarten: children achieved a greater understanding of scientific concepts when they learned about science through play, rather than through direct instruction [11]. By playing, children are intrinsically motivated, capable of maintaining high and long-lasting attention in their activity, and can internalize new insights through the repetition of and variation in actions [1,12].

However, children's free play alone—without a structure actively supplied through a teacher—is not sufficient to achieve subject-related learning goals [2,5,13–15]. It requires suitable play materials and content-related learning environments that engage children's interest but also make them curious to explore further and develop new experiences and insights [1]. Self-directed playing with materials and talking about them with other children or a teacher can bring the playing child into a cognitive disequilibrium. Such cognitive imbalances can be considered as the starting points of learning [16,17]. As per constructivist theory, learning means building on existing cognitive structures and rearranging them: synaptic connections are built, rebuilt, and broken apart. The basis for these neurobiological construction processes are sensory impressions, actions, social interactions, and reflection [18], which can also be triggered by playing.

To foster learning in play, the teacher should design an environment in kindergarten that meets some criteria. It should be orientated around the children's interests and the living world, around children's learning and development levels, and around learning goals. It should give children rich possibilities for acting with and handling materials, allowing for self-direction and differentiation to challenge but not overwhelm children. Social interaction should also be included in the playful learning environment to facilitate co-constructivist learning [2,19–21].

In addition to designing such playful learning environments, the teacher should closely observe children's play and engage with the interests and thoughts of the children. The teacher's task is to discover how a child can be further stimulated to learn through play and to provide the appropriate scaffolds. All of this is a challenging task and not easy to plan, as the teacher must be open-minded to the child's interests and needs in the play situation. It is important that the child always has the feeling of agency and autonomy during play. Thus, to encourage children in play, the teacher must find a balance between restraint and active engagement [2,22–25].

This article presents the theoretical concept of an innovative didactic approach for play-based physics learnings in kindergarten that aims to meet all these mentioned requirements. Subject-specific, play-based learning approaches are rarely mentioned in the literature and are not well known among teachers and experts of science didactics; therefore, we will show how a kindergarten teacher can stimulate physics-related learning moments starting from free play. First, we provide a theoretical overview of the concepts of playing and science learning separately, after which we bring playing and learning together as one unit; next, we consider curricular standards as well as methodological play approaches in early science education, identifying teacher training needs. Section 2 is devoted entirely to presenting the innovative didactic approach of the "je-desto" project. Using a concrete example, we provide insights into how play-based physics learning can be implemented in kindergarten practice. Finally, in Section 3, some experiences of this play-based learning approach are demonstrated and pedagogically reflected upon. In addition, the paper will report on how the didactic project "je-desto" in Bern, Switzerland, has been developed in the past and how it will move forward, focusing on the promotion of science learning in kindergarten free-play settings through training and familiarizing kindergarten teachers with this promising approach [26].

1.1. Children's Play

Play includes a wide variety of activities, and therefore it is not easy to define play [19]. Adults often define play simply as the opposite of work and see play as a typical leisure activity for children; by so doing, they position play as lesser than work. Seen differently, however, it is precisely play that is the occupation of children: their work, as it were [27]. Even the physicist Albert Einstein recognized the special value of play, expressing that play is the highest form of research. Moreover, the pedagogue Friedrich Fröbel stated that play is not just playfulness but has high seriousness and deep meaning [28]. The importance of play in childhood is underlined by the fact that the right to play was included in the UN Convention on the Rights of the Child [29]. Especially in early childhood, play is the key activity in promoting child development, not only in kindergarten but also outside of educational institutions [30]. The play activity of children is, as Einsiedler [31] mentioned, an intrinsically motivated behavior. It is an activity in which the process is more important than the results. In this context, Smith and Pellegrini (cited in [19]) distinguished play from work, as work focuses more on a defined goal.

The reason why children play is explained by several authors. Freud [32] mentioned that children's play has the function to help in processing conflict. Children repeat in their play what they perceive and experience in daily life, and abreact their impressions in play. Furthermore, they become masters of the situation. The child's self-control becomes characteristic of play activity. Children have agency in play [33,34]. Accordingly, if children aged four to six years were asked what play is, they would answer that it is the time of absence of their teachers [35].

According to Freud [32], play is something cathartic and positive for children's development, because it helps children to find an emotional balance as well as discovering how they fit into their environment. Erikson [36] focused on children's development of abilities in controlling reality during their play, and emphasizes that, due to play, children learn to participate and act in different, important real-life situations. Both Freud and Erikson understood play as an activity to handle real-life situations and conflicts [37]. In contrast, Jean Piaget's [38–40] explanation for why children play starkly differed from that of Freud and Erikson. Piaget did not assume that children adapt to reality through play, but that they adapt their reality in accordance with their interests or towards their ideas. He underlined the importance of not imposing restrictions in play; during play, children act in a self-determined fashion. In Piaget's view of play, assimilation becomes dominant when adapting reality. He supposed that children play because they would like to act in a way which counters the pressure of socialization and accommodation to the world of adults. Playing children protect themselves from disturbing external influences caused by restrictions of the adults. Assimilation is most apparent in symbolic play.

Similar to Piaget, Vygotsky also stated that, children transform the identity of one object into another one (imaginative object) during play, but he identified a different reason why children play. In Vygotsky's view [41,42], children play to fulfill wishes and desires. He stated that children have unrealistic desires and wishes, to be powerful in a similar manner to an adult in particular, and since they cannot realize their wishes and desires until they become real adults, they stage and realize their wishes and desires through their play in a social act. Children's wishes and desires are not yet differentiated, such as those of an adult, and this is evidenced in the (archaic) roles they take on (i.e., fireman, teacher, astronaut, superman, mom, etc.). According to Vygotsky, play is very important in human development because it leads to self-gratification: a child, for example, playing a fireman can save lives in play and derive satisfaction from doing so in an imaginary situation. Furthermore, it helps the child to use symbols and develop self-regulation. Vygotsky stated that play always takes place in the zone of proximal development. The zone of proximal development is the area of the nearest possible development. This would mean that an individual is capable of solving new problems with the help of an adult or a more competent peer. Vygotsky [43] aptly said: "In play a child is always above his average age, above his daily behavior; in play, it is as though he were a head taller than himself" (p. 102). Whether preprogrammed abilities are fully developed or not depends on social or cultural contexts. This means that it depends highly on how much other people are engaged or to which environment a child is exposed [43,44].

Leontjev [45] expanded upon Vygotsky's culture-historical theory including the activity-theory. From his point of view, the most crucial aspect of play it is not the behavior which can be observed directly, but the meaning and motive behind the behavior. The meaning and motive of the play can be revealed by understanding the child's developmental context and living environment. Leontjev claimed that play is the most important activity for preschoolaged children because it offers optimal conditions for developing cognitive functions.

Oerter [40] tried to define what play is and mentioned that the four most important characteristics of play are that it "ends in itself", and that there exists the "change of important aspects of reality", "repetitions and rituals", and the "reference to an object". By the characteristic "the play ends in itself", he understands that the player is fully focused on his actions or behavior and reaches a status similar to a full cognitive immersion or even a flow experience. Play is generally accompanied by positive emotions, such as interest or joy. However, it also means that the play is more important than the ends or that the process is more important than the goal. Regarding "change of kind of reality", he mentioned that, during play, the child distances himself from reality and provides activities and people with other meanings and rules, creating their own reality; imagination holds an important role. With the characteristic "repetitions and rituals", the fact that children excessively use play is considered, and so repetitions become a typical characteristic of play. Repetition is one of the most primitive ways of internalization, as already stated by Freud [46]; something that cannot be understood has to be repeated until it can be integrated free of contradictions in other thoughts and is understood cognitively and emotionally. Thus, repetitions are a rudimental form of learning. With the characteristic "object reference", it is mentioned that objects assume a central role in play. Often in the center of play, there is an object whose meaning is changed in the child's imagination, i.e., the stick which for some children becomes a sword. Objects in play can have, for example, a subjective valency, which means that an object has a certain significance and meaning for an individual, and that this meaning cannot be shared with others, i.e., the transitional object which many children bring to kindergarten at the beginning of their kindergarten career; these cuddly toys only have a special valency for their owner, which other children are usually not interested in. However, objects in play can also have an objective meaning. In this case, individuals share the meaning of an object with others. This could be its real meaning, but could also be an imaginative meaning, i.e., the stick that becomes a sword in a knight duel requires that children share the meaning that the stick is a sword [45].

On the basis of different definitions from other authors, Hauser [12] also defines features that are characteristic of play. According to Hauser, an activity must contain all of the following five characteristics to be considered as play: incomplete functionality, so-do-as-if, positive activation, repetition and variation, and relaxed atmosphere. With the characteristic "incompletely functional", he expresses something important and new: play is not purpose-free, as older definitions stated, but "incompletely functional", which means that play also has functional aspects, but is not entirely functional.

Unfortunately, it is not possible to scientifically prove that playing and learning are the same thing, but many studies clearly show that children who do not play or participate in play show various difficulties in the development of skills [47]. Play certainly is, according to Hauser, an important developmental motor for learning and has an educational value in itself [12].

1.2. Children's Science Learning

If we focus on physics learning as conceptual growth, conceptual change, or conceptual reconstruction, it becomes clear that it is an active cognitive process that must be proceeded in by children themselves with the help of social scaffolds. In this learning process, existing concepts as well as relationships between them are changed, replaced, modified, expanded, or assimilated by new cognition. It often requires a fundamental restructuring of naïve concepts into scientific concepts. However, research shows that it is not an abrupt change between naïve concepts and scientific concepts, but rather a gradual process that may include phases with so-called intermediate concepts and phases, where differing concepts exist in parallel. Accordingly, scientific conceptual development is a longer process, in which fragmentary or even false concepts are gradually developed via intermediate concepts with still limited explanatory power towards a scientific conceptual system [27,48–55]. Vosniadou [50,53] emphasizes that the transition from everyday concepts to scientific concepts is not an actual change, but rather a concept reconstruction that is by no means voluntary. Generally, conceptual development in science can take place when children recognize the limits of their concepts through active engagement with natural or technical phenomena, thereby being stimulated to rethink and try matters out to likely arrive at a more consistent and coherent interpretation of their observations. Finally, for the forming and naming of scientific categories and concepts, social scaffolds are important [48–55]. With the help of the teacher, children can gain "knowledge of scientific words to label and define their observations" [25] (p. 31).

According to Vygotsky's cultural-historical theory [56], the key to science learning is not cognitive conflict (between two thought processes in a child), as Piaget assumed, but social interactions with a more competent person [57]. Furthermore, Vygotsky emphasized that science learning can only take place if the given instructions are in the children's zone of proximal development and do not overtax them [58]. In his theory of concept formation, Vygotsky [56] distinguished between everyday concepts and scientific concepts, which have two distinct, but dialectically interconnected lines of development. While everyday concepts are directly related to the world of experience and spontaneously and unsystematically formed by the child, scientific concepts represent theoretical principles that are culturally formulated and transmitted via language in a structured, abstract, and general way. "The process of concept formation came to be understood as a complex process [...] involving constant movements from the general to the particular and from the particular to the general" [56] (p. 162). This statement means that abstract scientific concepts must move downward toward concrete phenomena and everyday concepts upward from phenomena to generalization. In so doing, both everyday concepts and scientific concepts can influence each other and transform the entire conceptual system of an individuum, improving the child's understanding. Therefore, the teacher's task in science lessons is to support the children in linking everyday concepts with scientific ones (and vice versa) [59]. Everyday concepts are more prominent during early childhood than scientific concepts; the situation is reversed, however, during schooling [56]. Thus, everyday concepts are important because they can "lay the foundation for higher-order scientific thinking" and for the learning of scientific concepts [59] (p. 1967).

Although categories and concepts describe the structure and organization of thinking, the recognition of cause–effect relationships brings a dynamic into the learning process because it links several categories and concepts. Already as infants, children can recognize causal relationships, and they improve this capacity continuously. At the age of four or five, children make significant progress in causal thinking, mastering, and incorporating all the basic principles of causal thinking [60,61]. Thus, it can be assumed that kindergarten children are able to understand simple scientific relationships and recognize simple physical laws. At this age, children have recognized that causes are necessary for certain effects, and often ask "why" questions [62]. If no cause is obvious, they actively look for one if the situation allows it [60,61]. In a chain reaction with dominoes, for example, four-year-old children demonstrated that they recognize which factors have an influence on the domino effect (e.g., the distance between the dominoes) and which do not (e.g., color of the dominoes). Sodian [63] concluded from this study that children can recognize the underlying relationships of certain effects (e.g., termination or continuation of a chain reaction).

In other studies, however, it became evident that kindergarten children can form correct one-dimensional comparative judgments, while two-dimensional comparative judgments are still challenging for them [64]. Thus, effects in which several variables have to be considered are more difficult for children to understand. At the kindergarten age, they usually refer only to one influencing variable when interpreting or estimating a certain effect, even if it is caused and influenced by multivariate factors [60,64]. In addition to these findings, further empirical studies [64,65] show that young children are more able to recognize direct proportional relationships (e.g., the more flowers in the flowerbed, the denser it is; the more batteries in the circuit, the brighter the light bulbs shine) than indirect proportional relationships (e.g., the larger the flowerbed, the less dense it is; the more light bulbs included in the circuit, the less bright they shine). Stavy and Tirosh [65] concluded, on the basis of several studies, that the rule "more A, more B" is already intuitively applied by young children (from about 5 years), and leads to successful answers to questions involving directly proportional relationships (i.e., the more ice cubes in a water glass, the colder the water; the more sugar in a water glass, the sweeter the water).

Characteristic of early science learning is action-oriented, discovery-based learning involving individual–constructive and dialogic–cooperative learning. Through their own experiences and social interactions, children construct and restructure their increasing knowledge on physical concepts, categories, relationships, and laws. The important thing here is to provide children with a learning environment that builds on their interests as well as prior knowledge and leads them into the zone of proximal development, providing openness for self-direction but also for appropriate supportive discussion, alternatively called scaffolding [18,48,66–68].

1.3. Implementing Play-Based Science Learning in Kindergarten

In recent decades, educational policy has increasingly called on teachers to foster academic standards, even in the early years. With this educational mission, play pedagogies became more and more important in their role as a developmentally appropriate method to achieve the curricula expectations already in kindergarten [1,10,11,25,59,69].

In most cantons of Switzerland, kindergarten is part of the compulsory schooling that take place over 11 years in three successive cycles. The two years of kindergarten and the first two years of primary school form cycle one. According to Swiss Curriculum 21, play-based learning is characteristic of 4–8-year-old children in cycle one. Especially in kindergarten, play is emphasized as the central form of learning, whereas during the school years, it is gradually replaced by more systematic learning [1]. A special feature of Curriculum 21 is that, for each subject, it predefines a progressive build-up of competencies that pupils are expected to develop cumulatively over the three cycles. This means that subject-specific competence expectations are already specified for kindergarten [1,70]. The physics-related competence formulations for cycle one are integrated into the interdisciplinary subject "nature-human-society", and map a small-step learning path in which the physical concepts can be increasingly expanded and differentiated [70]. Several studies [71–74] show, however, that cycle-one beginner trainee teachers generally do not enjoy teaching physics topics and often assume that physics is complex and difficult to understand. These attitudes and beliefs are often based on trainee teachers' experiences of systematic physics learning in school. As physics education in cycle one can be taught on a simple competence level and in a playful way, it is very important that kindergarten teachers acquire some insights in their training and further education into how they can support children in learning simple physical concepts and relationships through play.

International studies [10,11,59,75] show that even in-service teachers are often unfamiliar with didactic approaches that foster play-based science learning, and it can be stated that there is generally a lack of knowledge about how to use play to promote science learning. Furthermore, Bergen [76] detected that some "educators' perspective about play are limited to the developmental benefits of play but fail to consider the academic learning opportunities" [10] (p. 63). Such educators "implement child-directed free play without considering the role of the educator in extending the learning potential of this play and creating playful learning opportunities for children" [10] (p. 63). According to Edwards and Loveridge [77], it is also common that "teachers do not consciously recognize the learning opportunities existing in their preschool context because of a lack in pedagogical awareness of how to teach science in everyday preschool settings" [70] (p. 1965). Likewise, Gomes and Fleer [59] highlighted that "teachers in the same preschool settings have different levels of science awareness for the possibilities of informally teaching science" (p. 1961). Pyle [10] concluded therefore that "practitioners need to be taught" about play-based learning and that there is a need for "descriptions of diverse methods for implementing play in the learning environment" (p. 63). The findings of a study in Zurich, Switzerland, also show the need for Swiss kindergarten teachers to further develop play as a form of learning [6,78].

Different approaches to play-based science learning have been considered by international research. According to Tunnicliffe and Gkouskou [79] and Fleer [80], children exhibit science-specific behaviors during play activities and are able to become familiar in such situations with everyday science concepts. Therefore, Tunnicliffe and Gkouskou [79] recommendedfirst providing preschool children with free-choice activities in which science experiences are made before the teacher implements the "specific activities targeted to introduce a particular scientific concept" (p. 4). In this sense, Larson [81] emphasized the importance of capturing children's perspectives, motives, and interest in play, capitalizing on them for science learning. Moreover, Pramling Samuelsson, and Asplund Carlsson [82] generally advocated in their theory to start with children's experiences that allow variations and repetitions to discern a concept and gradually develop a conceptual understanding. In such a "playful learning environment, the teacher's intention is to get the child to think, reflect (think about their thinking), and verbalize" [11] (p. 229). Therefore, communication and meta-communication are important final stages of play-based learning, which the teacher must initiate [82].

In contrast, Sligoris and Almeida [83] suggested that teacher-guided play should take place before child-guided play. Teacher-guided play, can introduce children to science concepts and related terminology so that children know which science concepts to focus on and explore during child-guided play. However, results showed that an introduction at the beginning is not enough: "Teacher involvement during the child-guided play was also important to support the children's learning" [83] (p. 1590). In the end, it is always crucial that the teacher consciously connects children's play with "the science concepts, and the relationships between these" [83] (p. 1590). Following the cultural-historical theory of Vygotsky [56], Fleer [80] reached the same conclusion; she stated that playful events need the "teacher as mediator" so that everyday concepts and scientific concepts can be interlaced. She noted the following in a study: "When children are given progressively more everyday experiences [in playful events], without a corresponding matching of scientific concepts, then [...] children work horizontally only [at the level of everyday concepts] and do not engage in other ways of thinking as they interact with their environment" [80] (p. 301).

According to Fleer [84] "there is no model of play specifically developed to support science learning" (p. 3). Therefore she adopted the known approach of Playworlds into "a model of teaching science in play-based settings" and called it the Scientific Playworlds [84] (p. 1). This didactic approach shows "how scientific reasoning in guided imaginative play can be designed into play-based teaching programs so that preschool teachers intentionally engage young children in scientific thought in play-based settings" (p. 1). With this approach, the teacher is typically part of the play and helps to build a "collective imaginary situation" by telling a story and introducing the children to an "imaginary conceptual playworld space". In this context, the teacher defines the meaning of certain devices or tools and creates a problem set to be solved by the teacher and children entering into this playworld. Thus, in this model, the teacher not only influences the play setting but also the play development [85] (p. 5)—this "appears to be unique about playworlds" [84] (p. 3) and means that this play approach is strongly guided. Furthermore, "in this study, wonder was not something that was naturally within the child as a scientific way of interacting with the environment, but rather wonder was socially produced by the teachers through how they continually spoke about the environment, events, and introduced activities" [84] (p. 14). Overall, no matter which play-based approach is considered, it is crucial that the children build an emotional connection to the environment that motivates and engage them to further explore the scientific concepts [86]. "Without the establishment of a long-term relationship between the world of science and the child", a strong conceptual base cannot be built [84] (p. 64).

A project called "je-desto" [26] has been successfully utilized on another innovative approach for playful science learning over the last several years—even before introducing the new Swiss Curriculum 21. It is based in Bern, Switzerland and is presented in more detail in the following section. The project follows the general play-based learning approach of Pramling Samuelsson and Asplund Carlsson and other previously mentioned authors, where knowledge is to be developed on the basis of the children's experiences with materials and their variations. The central question of this new approach is how the tangibility of physical phenomena can be brought to light through the design of a didactic setting in which the children can encounter these phenomena in a self-directed way. The explicit naming of physical laws is deliberately not performed at the beginning, but after a self-directed, language-barrier-free, active and exploratory play period. Thus, language plays a different role in this approach than in the model of Scientific Playworlds [84], where the language represents a key competence for participating in a collective imaginary play.

2. An Innovative Didactic Approach for Play-Based Physics Learning in Kindergarten

2.1. Background and Aims of the "je-desto" Project

The "je-desto" project [26] was originally a grassroots movement from kindergarten practice in the canton of Bern, which, through years of development work, has established itself as a project funded several times by the Swiss Academies of Arts and Sciences. The impetus for this play-based physics learning approach was the recurring question asked by children in group discussions or instructive settings: "When can we go and play"? The project started in a kindergarten in Bern, with a kindergarten teacher, Nathalie Glauser-Abou Ismail, who had the idea to integrate science learning into kindergarten free play. Consequently, there were numerous stimulating discussions among the team and teaching staff on how to achieve this integration. The pivotal points are the physical laws, which should be experienced by the children independently through play. In other words, it should not be the teacher who familiarizes the children with these physical laws; instead, the play environment itself should lead them to these insights. More and more interested colleagues have joined this project and have entered into an exchange to create suitable playing environments that are stimulating and educational for children, but that also allows a wide variety of play options. Since 2013, the "je-desto" project has been developing evidence-based free-play activities to promote STEM (science, technology, engineering, and mathematics) at the kindergarten level.

The didactic approach of "je-desto" is based on the following characteristics of learning theory and competence-oriented teaching [68]: (I) The development of competencies is understood as a continuous, cumulative process, which, however, proceeds very differently for individual children. With regard to kindergarten, it must be assumed here that, due to the very different previous experiences of the children, competence building starts in very different places and at different times. Kindergarten teachers must first be able to obtain an overview of the different stages of prior knowledge. (II) Assuming that people always learn based on and connected to their previous experiences and beliefs, it is important to have both insights into learners' prior understanding at the beginning of the lesson and insights into the corresponding changes and competence developments during the course of the lesson. (III) Competence orientated learning opportunities should help children to perceive and understand situations as actively as possible, and to act accordingly. The new applied knowledge should be transfered to new situations. (IV) Learning opportunities should be open enough so that they can be used in different phases of development. However, they should also contain structuring aids for the procedure and the content. (V) It is important that teachers adaptively accompany learning processes, i.e., they should support learning processes along children's respective levels of cognition and, starting from there, lead them into the zone of proximal development. (VI) The concepts learnt are co-constructed, based on experiences and social interactions, and are transmitted via language. For children in kindergarten, learning subject-specific content, therefore, also means learning language, because their vocabulary has to be developed.

Thus, the didactic approach of the "je-desto" project has several objectives. First, it aims to realize a didactic setting for play-based physics learning that allows kindergarten teachers to capture and take into account kindergarten children's different development levels. Second, it aims to offer kindergarten children a play environment where they can experience and recognize physical laws in a self-directed, action-oriented, and playful manner. Third, it demonstrates how kindergarten teachers can adaptively accompany children's play and learning process, finally leading to the naming of self-discovered scientific laws in the play environment. Beyond that, the "je-desto" project itself aims to familiarize kindergarten teachers with this innovative didactic approach, so that they are able to implement play-based environments in kindergarten, which will promote science learning in young children.

The special methodological feature of the "je-desto" project is that it takes free play into account as a structural element that has an impact on learning, and thus shows new possibilities for promoting subject competence in an age-appropriate way. Therefore, the offerings of play for competence promotion should not only be enriched in terms of subject didactics, but they should also be somewhat nonfunctional, because incomplete functionality in children's play processes is—followings Hauser's definition [12]—an essential characteristic of play.

However, in this context, a differentiated interpretation of "free" play in kindergarten should be emphasized. In many respects, free play in an institutional setting is anything but free: it depends, among other things, on many structural circumstances, such as the spatial conditions, the resources and materials available, the social structure and relationship cultures in the class, and, last but not least, the teacher's understanding of their role during the free-play phase. This understanding of the teacher's role is expressed, on the one hand, in the time frame that the teacher makes available to the children on a daily basis, and surveys have shown that the actual number of minutes per unit varies greatly from kindergarten to kindergarten. Various authors [7,12,87] state that immersion in play processes requires time, and that this should not be displaced by instructional, goal-oriented learning. Instead of this, in the approach of the "je-desto" project, it is stated that the free-play time should be used as fruitfully and meaningfully as possible, for the development of competences. Free play has several advantages for learning. The children show in the free-play time their highest level of activity and do not need external reinforcers, because the play itself is fun for children, and thus, it is joyfully repeated and varied by the children themselves.

In the following sections, an example from the free-play settings of the "je-desto" project is used to describe how free-play situations can be designed to enable self-directed physical learning (Section 2.2). The sections also show how the teacher can offer the child feedback during play (Section 2.3), and how the child can ultimately move from experiencing to recognizing and naming physical laws (Section 2.4). Finally, the special role of the morphosyntactic structure "je-desto" (the more . . . ., the . . .), which gives the project its name, is described (Section 2.5).

2.2. Designing a Free-Play Setting with Science Learning Potential

The preparing of a free-play environment is central to implementing the didactic method of the "je-desto" project. A designed free-play corner in the kindergarten invites the children to engage with experiences from their lifeworld and is oriented towards science-related competencies. Thus, it creates a clear framework for the children as well as the teacher, in which, however, there is still enough openness for self-directed playing and individualized learning.

Let us take the free-play idea CINEMA as an example: here, the optical phenomena can be played with. For this free-play activity, an overhead projector, a large cloth, a curtain rail, and a tape are needed—as is space, for example, a corridor. A railway track is stuck to the floor with tape, and the overhead projector is placed on a low wooden trolley so that it can be played with at the children's height and moved back and forth on the stuck-on railway track. A sheet hung on a curtain rail becomes a screen that can be pulled or pushed aside as needed (see Figure 1). Behind the curtain there is a row of chairs, where children in the role of spectators can sit and watch a "cinema movie", only seeing the optical phenomena that are projected on the screen by some children on the other side of the curtain. For these projections, the teacher can provide various materials such as the followings: two- and three-dimensional figures, and colored or color-printed foils, which could be placed on top of each other. The number of variants in objects can deliberately be reduced or expanded—potentially by the children themselves.

Figure 1. Free-play setting CINEMA.

This environmental setting in a kindergarten allows for many different play situations and stations at the same time: children can place any or given objects on the operating overhead projector and observe on the screen how the three-dimensional objects are transformed into two-dimensional shadows/projections in plan, elevation, and side elevation. In the space between the overhead projector and the screen, children can play shadow theatre. Behind the screen, watching children can sit and marvel at what is happening on the screen (see Figure 2).

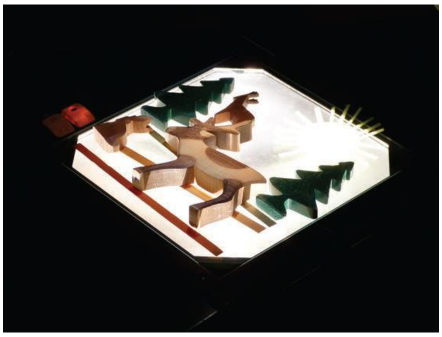


Figure 2. Before the curtain: creating own scenes on the overhead projector. Behind the curtain: watching the created scenes on the screen in the free-play CINEMA.

The play design in the different locations of the CINEMA setting can be very different, and depends entirely on the child or the group of children. Different play and learning focuses can already be observed at the overhead projector: some children will only look at the objects on the overhead projector and marvel at the light (in)transmission of the objects, while others will only look at the projections on the screen and control their eye–hand coordination entirely through this spatial optical phenomenon. On the overhead projector, several objects can be related to each other, and even small scenes can be created with the figures and their respective projections—during such play, children can find out how figures must be placed on the projector so that they also become visible as figures on the screen, or that, surprisingly, even new, abstract figures will emerge in the projections, depending on how they place an object (see Figure 3). Some children may not even bother with the question of representation on the screen and just play with the figures on the projector, or they may build towers with the objects. This is legitimate in free play, and is hence allowed.

Figure 3. Playful exploration of shape, color, size, and proportions in the free-play CINEMA.

Of course, on the other hand, in the free-play CINEMA setting, there will also be children who were very impressed by the fact that such small figures on the projector can become large projections on the screen. A child can also take a similar play figure and hold it up to the representation on the screen to better grasp the difference in size (see Figure 3). Maybe they will also come up with the idea of making the projection of the figure even bigger, or as small as possible. Randomly or deliberately moving the overhead projector placed on the trolley can create new possibilities in the free play. Additionally, the children can recognize, by playing in the CINEMA, the rule "the more . . . , the . . . ": the further the overhead projector is from the screen, the larger the projection; the closer the overhead projector is to the screen, the smaller the projection.

In the space between the overhead projector and the screen, a further rule of "the more . . . , the . . . " can be recognized sooner or later when children play shadow theatre. Some children often prefer this setting to play shadow theatre with other children; maybe even in front of a backdrop created by other children on the overhead projector. They can try to play conscious scenes or just move freely in this space. In the beginning, many children simply enjoy performing or dancing for the other children behind the screen. Through various body movements, as well as moving forward and backward, they will casually realize that their shadow is changing—including in size. Thus, playing with peers can be an important activation mechanism and a possible source of motivation of the offerings of free play. In this social context, physics-specific learning can become accessible and interesting, because children can have their first emotionally positive experiences in a subject-specific learning field, together with their friends. The railway track glued to the floor between the overhead projector and the screen supports some children to already orientate themselves and note that the size of their shadow changes with their position in the room; the closer to the light source a child's body, the larger the shadow on the screen.

Behind the screen, the watching children sit and marvel at what is happening on the screen. Some children will remain seated. Others will go to the screen, somewhat cheekily, and look behind the curtain at what causes this to happen. Alternatively, to put it another way: they are in a cognitive disequilibrium and therefore check their concepts.

Finally, as soon as the light of the overhead projector is turned off, the projections and shadows disappear, and the cinema performance is over—but only until the next free-play sequence in the CINEMA begins.

As a typical feature of a competence-oriented learning setting, the content is open in the free-play setting CINEMA, and the focus can be set by the learners themselves. Regardless of the focus of the chosen activity, the ray theorem of optics is effective in this free-play offer.

In contrast to other learning environments, a free-play learning environment makes it possible to experience specific subject content without the teacher being present, controlling or directing the children's play processes. Nevertheless, the teacher had, in advance, the important task of designing such a free-play setting, where it is possible to experience and recognize various physical laws through free-play activities.

The free-play idea CINEMA establishes a relationship to the living world of children. It embodies part of the basic conditions of children growing up, such as imprinting through visuals, two-dimensional experiences, and media experiences. The way in which this relationship to the world of life is represented is fundamentally open. The focus is on creating an experiential space in which children can experience, recognize, and name physical relationships and laws. In the free-play activity CINEMA, there were reliable expressions of the rule "the more . . . , the . . . " of optics: the closer I am to the light source, the bigger my shadow falls on the screen; the further away the overhead projector is from the screen, the bigger the projection of the figure is on the screen. Numerous causal relationships could also be established, for example, if there is no light, then there is no projection/shadow; if the object is opaque, then the projection is colorless; when colored foils are placed on the projector, colored projections are created on the screen; and if there is no figure on the projector or in the projection room, there is no contrasting projection/shadow.

In this way, the free-play idea CINEMA is also oriented towards the Curriculum 21 competencies on optical phenomena; for cycle one, a competence expectation is namely that pupils can investigate, compare, and describe light as well as shadow phenomena in a guided manner [70]. This orientation towards subject competencies is important in creating a setting in which children can express their prior subject knowledge in play and find the opportunity to expand their subject competencies in the same setting; it is not about forcing children to engage with physics in their free-play time. Children are free in their choice of play; they can, if they wish, concentrate solely on their play with figures or on building towers, for example, even in the CINEMA. However, the designed play environment has a clear goal: it works reliably and is always ready for the moment when a child will be ready to have their "teachable moment".

As already stated by Neutert [88]: play creates its own reality: that of possibilities. Regardless of whether the children begin with playing with figures or building towers in the CINEMA, the design of the free-play corner enables them to grow into an engagement with optical phenomena, to help determine whether and how differently they engage with them. The designed free-play area carries the seed of possibilities, but it is the playing child who creates his/her reality. In other words, free-play corners are a symbol of proximal development.

2.3. Play Supervision: Between Chosen Restraint and Formative Learning Feedback

In free play, children are autonomous and self-active, their inner selves express themselves in their actions. Through observation and dialogue, the teachers learn where the children are and thus where teachers can start and lead regarding developmental or subject-related goals. It is important to repeat that the teacher's restraint is a chosen role, not a forfeiting one—in the play-based physics learning approach, according to the "je-desto" project, the teacher never directly instructs the child, but at most stimulates them in playing to find something out for themself or to become aware of something.

The basis of all further play and learning guidance is the observation of a child's play processes. The "je-desto" project has been able to link these play processes to a silent form of preconcept elicitation. If preconceptions are collected before an actual lesson, younger children, in particular, are exposed to a great burden that often weighs heavier than the effective expression of their prior knowledge. This is because the expressiveness of the performance of young children depends on the given structure. If, for example, kindergarten children are asked about their prior knowledge of optical phenomena purely via language (i.e., without any further structure), the yield as an indication of the children's effective prior knowledge is likely to be meagre. If, on the other hand, the children are asked about their prior knowledge in an existing structure, such as the free-play CINEMA, they have more possibilities than just the tool of language to express their knowledge: they can show it concretely. Experiences from the "je-desto" project have shown that even "silent" preconcept surveys, through observing the children playing in the setting, allow certain conclusions to be drawn, in the sense that these observations are at least reliable and can be connected to further questions in the context of play and learning support.

However, the individual learning level of children can also be assessed in a more targeted manner, for example, by carrying out a simple, concrete play challenge, which can at the same time also provide a learning stimulus. A possible challenge that could be posed to the children in the free-play activity CINEMA is the question of how a human being can hide behind a small toy wooden fir tree. The children can answer this question with their actions, i.e., their play. As these are play processes, they can be open-ended in terms of access and outcome. Hauser [12] demonstrated that children are more willing to take risks and set higher goals for themselves when the challenges are presented to them not in the form of a task but in a playful manner, which massively increases the chances of effective learning gains.

Through the different play processes and approaches that emerge from this stimulus, the teacher can adjust his or her feedback based on the observations. Importantly, feedback refers always to the learning process, to the path or gap to be overcome to achieve a learning goal. There are different forms of feedback that a teacher can give in the process support and, depending on the developmental stage or competence level, a different form of feedback is helpful. Following Hattie's [8,89] comments on formative feedback, the following three levels of feedback forms have emerged in the context of the "je-desto" project:

The children who seem lost in their play regarding the challenging stimulus need immediate feedback that directly relates to the challenge. Children's attention should be drawn to what can or should be enacted here. In the case about hiding behind the toy fir tree, this could mean, for example, asking the child where the wooden fir tree could be placed in the CINEMA setting. Afterwards, it might be possible to ask how the fir tree could be placed on the overhead projector so that it is visible on the screen in the elevation. It should be emphasized that it is important for teachers to be aware of this option of play facilitation, and at the same time know that it is not always necessary to use it on such an individual level. Some peers will most likely choose such an approach in their play anyway, and a pronounced affirmation might encourage other children to follow suit.

More experienced children, on the other hand, prefer strategy-based feedback that helps them deepen their learning. In the challenge with the wooden fir, it could be asked, for example, what options are available to make a shadow/projection bigger or smaller. For some children, this hint will be enough to come to the realization that they can themselves move along the glued-on railway track, and that the further away they stand from the light source, the smaller their shadow will become, until they can visually hide behind the projection of the small wooden fir. Another possibility in this context would be to move the light source, i.e., the overhead projector on the wooden trolley, further away from the screen, without the children having to move. Alternatively, a combination of both may be used. In this phase of learning, the free-play setting itself provides helpful feedback to the child as to whether he or she is on the right path or not.

Finally, the experts among the children—who master the challenge on their own by trying different strategies and ways of doing things—benefit from advisory feedback, especially to develop metacognitive competences that enable them to steer themselves. For experts, time also plays a different role: the feedback does not have to be received immediately, and sometimes a certain time delay even helps to achieve more abstraction. Concerning the question, it can be discussed with the children how they proceeded, which conclusions and analogies they drew, or which transfers could still be drawn.

Through this structure of feedback based on the needs of the children, a fit is achieved in process support, as required by competence-oriented teaching. However, it must be mentioned that the provision of feedback is not a one-way street that runs from the teacher to the pupil. This was also stated explicitly by Hattie [8,89]. A teacher's feedback is only half the story: feedback includes as much feedback from the children to the teacher to shape and guide the processes. Young children often cannot put this directly into words, but teachers can become aware of the fact that play behavior is not only dependent on prerequisites, but also on the possibilities that are available; thus, observations of the play processes not least also allow for any need for adaptation in the design of the play environment.

As a concrete example of how such play is supervised, the following presents a play sequence that occurred in the free-play setting CINEMA. The theme that the children chose to play in was the "railway".

While three children are playing on the overhead projector, they place trains on the top of it and become enthusiastic that they can see the locomotives and wagons on the screen. After a while, they begin to move the locomotive forward by hand on the overhead projector until a child has the idea to push the overhead projector itself. The children are delighted because in this way their hand is no longer visible on the screen. Over a longer period, the children, make the train move forward, sideways, and so forth. Thus, they can observe how the projection of the train becomes smaller and larger or even disappears from the scene altogether. Meanwhile, they imitate the locomotive sounds "Sh-sh-sh". Then, they stop moving the overhead projector and begin to place wooden rails on it, but they struggle to place the wooden rails in such a way that they appear projected as rails on the screen. While two children eagerly try out how it can be achieved, the third child plays shadow theatre, imitating the conductor; the child suddenly calls out, "Look, if I take a few steps and make myself small, I disappear, and it will look as if I am really sitting in the wagon". The other children are thrilled, abandon the wooden rails, and immediately want to demonstrate "getting into the wagon" to the teacher and the other children who gather behind the curtain. After the CINEMA demonstration, the teacher curiously asks the children how they went about it. One child stated: "Just take a few steps like this and then hunch over and keep your head down, then you will not see me anymore". The teacher listens to the children's words and asks them to describe exactly where these steps are taken. With further questions, she leads the conversation until the children themselves can say precisely where on the floor they have taken these steps and where the overhead projector stands at that moment. Wow! The teacher is fascinated. To stimulate the children's play and learning further, she also asks if it would be possible to stand further back or forward. Or: It is possible that the passenger, when they disembark from the train, can also disappear into the railway station building?

This example illustrates that it is important to immerse themselves in the children's play and to build up the physical laws of optics on the basis of the content that is meaningful for those children. In this case, it is not a tree that someone hides behind but the train or the railway station. Thus, in the CINEMA example, the same playing environment, can offer children various possibilities for actions, interactions, and meaning-making.

2.4. Playful Proccesses to Cognition/KnowledgePhysical Laws

Play processes are open processes, e.g., they are open-ended. Play processes also open up to the teacher what is normally hidden in the child and cannot yet be expressed through language; the child shows this in their actions. Children determine the course of their play processes. However, all this openness does not mean that play is random. Careful play design and needs-based play support enable children to profoundly expand their competencies or even reconstruct concepts in their play processes; children go through a process of awareness that we divide within the framework of the "je-desto" project into "experiencing", "recognizing", and "naming"—in analogy to Scheiblauer's approach of rhythmic didactics [90], which consider several insights and findings from cognitive psychology. Before describing this three-step process, however, we clarify the concept of tangibility, which forms the basis for it. Tangibility as a concept, borrowed from the discipline of rhythm and music, means *let forces work and perceive the physical laws with all* *senses*. Translated into the didactics of science, this clarifies the demand on a free-play offer to allow the tangibility of physical laws and to enable children to play with them before they have been consciously learned and understood. In this sense, tangibility is not a matter of practicing or applying physical laws, but rather of experiencing them.

Experiencing emphasizes the lived moment: it means becoming aware of cause and effect produced by manipulating objects. Experiencing means also allowing things to work and perceiving the effects [90]. It can be considered sensorimotor learning or sensory-perceptual learning. Through interacting with and perceiving the environment, individuals build up experiences, which are considered as processed perceptions [91].

Recognition represents a higher-level process than experiencing. In the three-step model by Scheiblauer [90], it represents the transition between unreflective action and linguistic reflection. Hajos [92] defined the act of recognition as a conscious and active cognitive process that includes and categorizes a percept within the entirety of an individual's networks of experience and knowledge. Katzenberger [93] specified that this categorization and inclusion of a percept could only occur when the meaning is understood. Recognition is also a pre-linguistic process. It allows a person to assign an action, that is, to have insights into a law and the capacity to apply it [90].

Finally, *naming* is the act of taking linguistic possession of the learned content [90]. It allows for the sharing of content with the social environment. Naming means expression; linguistical expression, but not only linguistical. Being able to name means that knowledge complexes are organized. Thus, language facilitates communication and restructures the thinking generated from practical activity or perception. What can be grasped and expressed linguistically, the child has abstracted [56,90]. A prerequisite of naming is symbol-based cognition [38]: naming something means that a representation or a semantic network has been labelled by a verbal expression. Bak [94] described language as a large encyclopedia used to identify and become aware of objects, situations, and relations. According to Halliday [95], language is "the essential condition of knowing, the process by which experience becomes knowledge" [95] (p. 94). Therefore, experiences and recognitions should be linked with words. They must be named to become linguistically tangible. Otherwise, they will remain as diffuse impressions [96].

The following examples summarize the main points: An *experience* in the CINEMA free-play setting is the size of the children's shadows that change. The *recognition* is then that the shadow size depends on where the children are located, or more precisely, how far they are standing away from the light projector. Finally, *naming* could look like this: "The closer someone/something stands to the light projector, the bigger its/his/her shadow is on the screen." Thus, in general terms, the "je-desto" project focuses on experiencing, recognizing, and being able to name relationships and laws in physics. The children should experience the "the more . . . , the . . . " behind the physical phenomena, recognize it and, with the teacher's help, put it into a language to be able to communicate.

It is supposed that all children can benefit from the play-based learning environment in the "je-desto" project, although at different levels. Basically, children can have sensory experiences, perceiving light and shadow, or simply exploring the provided material in the play environment, such as the overhead-projector or the screen projections. In this scenario, children conduct a sensorimotor activity, which is already possible in the early stages of development. However, children are also able to recognize optical phenomena and include them in their semantic networks to successfully reproduce optical phenomena by manipulating the variables by themselves. In so doing, children begin to become familiar with the "je-desto" rule of optics. Ideally, children can verbally label their perceptions and cognitions. This verbalization requires the capability to use symbols and is therefore a higher-level operation. At this level, children are then able to communicate their experiences and insights regarding optical phenomena with others.

2.5. Morphosyntactic Structures to Support Subject Language Learning

A characteristic of the "je-desto" free-play offer is that there are no language barriers that block subject-specific learning. In the free-play CINEMA setting, children can play and engage with optical phenomena without the active or passive use of language [26]. This language-free access is of great importance in terms of educational participation and has a strong integrative effect. However, language learning is of central importance in the science subject. In fact, language is of such importance that new didactic approaches have specifically addressed the promotion of language in the subject [97,98]. Moreover, the Swiss curriculum for kindergarten and primary school specify the task of concept formation in science education, which is linked to language development [1,70].

By offering children the morpho-syntactical scaffold "the more . . . , the . . . ", the teacher provides children with a linguistic structure for expressing the recognized physical law. Once children have internalized that morpho-syntactical structure, they can use and apply it in a variety of contexts. In this way, the teacher extends children's linguistic capabilities to communicate about physical phenomena and laws [98–100]. The two terms "morphology" and "syntax" that form the term "morphosyntax" deal with how words are formed, combined and then formed in phrases, clauses, or sentences [101]. According to Chomsky [102], the syntactic structure is essential for illustrating the semantics of a sentence. Furthermore, research [97] has shown that vocabulary acquisition is particularly promising when the new words to be learned are embedded in sentence structures, such as "the more . . . , the . . . ". In this way, new words more easily find their place in semantic networks, which then can be adapted by the accommodation; thus, new words can be integrated into existing structures [94,99,103].

In the process of sustained shared thinking [25], the teacher should support and encourage the children to verbalize their experiences and insights. A concrete example shows how this can be achieved: when the children describe where in the room they have positioned themselves so that they can disappear in the railway wagon or behind the fir tree, the teacher can challenge the children with follow-up questions. For example, the teacher can ask how the size of the shadow/projection changes depending on which direction one moves on the taped lines on the floor. The morphosyntactic structure "the more . . . , the . . . " is in this context an important linguistic structural aid. The teacher can start by saying: "the closer you go to the light source, the more..." and let the children complete the sentence. It is helpful to say this right away in the play CINEMA setting so that the children can check their nonverbal or verbal statements directly through their actions. However, also more abstract forms of play supervision are possible, including only a linguistic exchange about the children's experiences without being directly in the play environment; this has to be decided in the situation and can be different depending on the group of children.

Practice showed that children with a low knowledge of the German language could also express their physical learning if they could refer to the morphosyntactic structure "je-desto" (the more . . . , the . . .). For example, the kindergarten children can express the "the more . . . , the . . . " rule linguistically and actively by walking near the projector while saying "the closer . . . " and then pointing at the screen when they say "the . . . " indicating something large with a movement of their arm. This non-verbal expression may not be a complete expression from a professional point of view, but it is a correct, connectable approach, as well as an amazing achievement for young children, especially if they have a different mother tongue. By naming the children's activities while engaged in sustained shared-thinking, the teacher can familiarize the children with the appropriate technical terms thus enabling them to internalize and actively use those expressions in other situations.

Playing in the CINEMA setting offers the opportunity to train for basic vocabulary as well as to specifically promote technical and educational vocabulary. As with all teaching units, from a linguistic point of view, a linguistic catalogue should be compiled for the free-play activities during the planning phase. This catalogue should include phrases such as "the more . . . , the . . . " and other sentence building blocks, as well as selected terms that the teacher will use again and again during the play activities, which will thus sustainably support the children in their professional language activities in the fields of physics.

3. Review and Outlook of the "je-desto" Project

With the free-play example CINEMA of the didactic development project "je-desto" [26], we have shown an approach for play-based physics learning in kindergarten that is empirically and theoretically funded. It allows for the promotion of physics competences in a playful way, where the children always keeps their agency (see Section 1). The teacher has a restrained role, but not a passive one, and also not an instructing one. The teacher creates the framework and the conditions for learning by providing a structure in play spaces in which simple physical laws act; the children themselves decide when they are ready to delve into it (see Section 2.2). In the play process of the "je-desto" free-play activities, the effects of simple scientific laws are experienced through playful actions, which can then be more specifically recognized and ultimately named (see Section 2.4). The teacher accompanies this process by providing supportive feedback and simple assistance—especially with regard to verbalization (see Section 2.3). In this context, the title of the "je-desto" project, namely "the more . . . , the . . . ", not only expresses the law of physics, but is also a morphosyntactic structure that allows children to express their insights/cognitions in a more general and structured form (see Section 2.5).

Following the constructivism learning theory, the aim of the "je-desto" play-based learning approach is not the inculcation of scientific knowledge, but the initiation of gradual concept formation in the individual (see Sections 1.2 and 2.1). It fosters an interest in thinking about the world and its relationships and laws—based on one's own play experiences, which are then reflected upon together with the teacher. The children's actions reveal to the teacher their level of development and cognition. Thus, through observation and conversation, it becomes clear whether children are experiencing physical laws, still trying out all possible or impossible combinations, or whether they already have recognized the underlying physical law and are applying it purposefully.

Furthermore, the play-based learning environments of the "je-desto" project allow children to take on different roles, pretend, repeat and vary their activity, and finally also immers themselves in a context that is meaningful, interesting, and engaging. The freely chosen play provides positive emotions that guide the process of play and learning [12]; see Section 1.1. Various teachers of the "je-desto" project have remarked that children enjoy playing in the "je-desto" free-play settings. Notably, they stated in the development and testing phase that play activities with a purely scientific orientation appealed to fewer children than play activities that enabled scientific learning while also allowing the children the freedom to engage in the emotional, social, and aesthetic, dimensions of the role play.

In addition to the CINEMA example described in detail above, more than twenty other free-play activities that follow the "the more . . . , the . . . " logic have been developed in recent years—not only in regard to physics learning, but also to other areas of science, technology, engineering, and mathematics (STEM). In the free-play activity "Music Corner", for example, children can experience the relationship between string and pitch: the longer the string, the deeper the pitch (carried out with the same string diameter, the same tension force, and the same material density); the higher the tension force, the higher the pitch; and the thinner the string, the higher the pitch. All the developed free-play examples are freely accessible on the project homepage (www.je-desto.ch) [26], and are actively used in everyday teaching, but also in the training and further education of teachers.

The "je-desto" project has grown into a loose network, now with over 250 participating teachers and established STEM experts from various Swiss colleges and universities. This actively cultivated dialogue between teachers and experts, financed by the Swiss Academies of Arts and Sciences, guarantees both the technical correctness as well as the level-specific and everyday conditions for the success of the play settings offered. The "je-desto" project started small, but over the years it has attracted more and more teachers who are convinced and enthusiastic about this approach. The didactic approach of learning about physics through the child's own play has been met with positive responses. It hasalso attracted teachers who previously had reservations about teaching natural sciences in kindergarten, either because they lacked interest or did not trust themselves to integrate physical-technical content into the lessons. Several kindergarten teachers reported that they "never have imagined that they would one day integrate physical-technical content into everyday kindergarten life". They are very grateful for this open-accessible play-based science learning approach and for the exchange with other teachers and science didactic professionals.

At the beginning, in 2013, it was only one kindergarten team that was developing individual play-based learning settings. The difficulty has always been to design the play settings in such a way to make subject learning correctly tangible. Therefore, consultations with physicists were soon part of the development process, but this consultations were informal and on a voluntary basis. In the team, this idea of joint lesson development was met with great interest. Knowing that it was not the result of pressure from outside, but rather the idea that the "mechanics behind things" can be made accessible to the children in a playful manner, the project met the effective demands and possibilities of the kindergarten level from the very beginning. This was and still is the cornerstone of its success. Word soon spread beyond the school district to the entire canton of Bern, and a homepage was set up to facilitate communication and coordination with interested colleagues.

Thanks to external project funding, the "je-desto" project saw an acceleration in development during the school year 2015/16 of further free-play ideas for science learning. Sixty-two kindergarten teachers from 22 kindergarten classes were recruited to develop their own "je-desto" free-play setting and to test it empirically in their kindergarten group. The development and testing phase were supported by the "je-desto" project members and, if required, by STEM experts. These developed free-play ideas were collected and made available to other teachers.

In the second funding period 2018/2019, the focus was on reviewing these free-play ideas and further development of play support. At a World Café, 168 teachers and STEM experts reflected on scientifically based and age-appropriate forms of play support. The participating kindergarten teachers often expressed that "the exchange in this large community and with experts was very inspiring" and that it gave them not only "new ideas for teaching", but above all "the assurance that what they are doing is technically correct". The discussed free-play ideas were finally revised and more precisely articulated in a script for practitioners.

Since 2016, there were also offered further training courses for kindergarten teachers at the University of Teacher Education Bern. The focus of these training sessions was first on presenting the existing, developed free-play settings, as well as providing insights into the theoretical and pedagogical framework of this play-based learning approach. Since 2019, the further training courses have focused more on the play supervision and accompaniment. In total, more than 700 teachers participated in at least one further training course. With the introduction of the new kindergarten and school curriculum in canton Bern in 2018, the Bern Department of Education and Culture has provided various supporting materials for implementing learning environments and subject-related tasks in kindergarten, and has also referred to the didactic approach of the "je-desto" project [104].

In 2021, the "je-desto" project was promised further funding from the Swiss Academies of Arts and Sciences. As a result, further attention will be paid to scaling the project;namely, the expansion and cooperation across Swiss cantonal borders will be strengthened, familiarizing other German-speaking cantons as well as French- and Italian-speaking cantons with this special didactic approach. By also sharing this didactic approach in English-language journals, the play-based learning approach of the project "je-desto" should become accessible worldwide. Therefore, a translation of the free-play ideas into several languages is planned for the future. Obviously, the social and cultural contexts must always be considered when applying the ideas of play-based learning settings elsewhere, and the play environment should be adapted if necessary.

When the project was launched a good ten years ago, the Swiss Conference of Rectors of Universities of Teacher Education (COHEP) analyzed the state of the subject didactics in Switzerland at that time. At a conference in 2013, organized by the Zurich University of Teacher Education, the Swiss Conference of Cantonal Ministers of Education (EDK), the Aebli Näf Foundation for the Promotion of Teacher Education in Switzerland, the Swiss Society for Teacher Education (SGL), and the Swiss Conference of Rectors of Universities of Teacher Education, Adamina [105] described a clear need for the further development of subject didactics, especially for kindergarten and primary school. In addition, it was stated that most didactic projects often act in isolation, were often fragmented, and were without a theoretical foundation or clear methodological profile.

The development project "je-desto" is an innovative didactic project that closes a gap in this area. In the course of the last ten years, it has not lost any of its innovation: the promotion of science subject competence in free-play settings remains a unique feature (see Section 1.3). In the free-play offers from "je-desto", subject content is didactically reconstructed in such a manner that it becomes accessible in an age-appropriate way, namely in play. The play itself also allows for children's preconceptions to be elicited and stimulates effective learning processes to take place fluently in the same setting, which meets the desiderata of the continuous alignment of prerequisites and content to be learned in the context of didactic reconstruction. However, further research is needed. A scientifically based evaluation of this play-based learning approach is targeted, and empirical research is still ongoing in this regard. We are working on publishing an analysis of kindergarten teachers' experiences with this play-based learning approach in a subsequent paper. Furthermore, we would like to investigate the long-lasting learning effect of such play settings by conducting follow-up interviews with children. Moreover, the next development step that the project team will take is addressing the question of how the play and learning processes can be documented and thus made even more comprehensible for others.

Finally, there is no question about the great learning potential of these free-play settings. The free-play settings of the "je-desto" project offer language-conscious physics learning that successively promote educational language with the help of the morphosyntactic structure. In addition, the domain-specific thinking of physics and problem-solving behavior can be practiced in free-play offerings in accordance with the requirements of competence-oriented teaching; the content-related insights into physics can be conneced to the in-depth structured subject learning at higher school levels. Furthermore, and last but not least, the free-play activities do not reify any gender stereotypes; instead, they make it easier for girls and boys to have their first emotionally positive and conscious encounter with physics in kindergarten.

Author Contributions: All three authors have contributed equally to all parts of the article. All authors have read and agreed to the published version of the manuscript.

Funding: The "je-desto" project was funded by the Swiss Academics of Arts and Sciences. The article was published with the financial supported of the University of Teacher Education Bern.

Informed Consent Statement: Informed consent was obtained from all parents of the subjects pictured in the photos.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Erziehungsdirektion des Kanton Berns (Ed.) *Lehrplan 21—Grundlagen*; Gassmann Print: Biel/Bienne, Switzerland, 2016.
2. Kübler, M.; Buhl, G.; Rüdisüli, C. *Spielen und Lernen Verbinden—Mit Spielbasierten Lernumgebungen*; Hep: Bern, Switzerland, 2020.
3. Pramlin Samuelsson, I.; Johansson, E. Play and Learning—Inseparable Dimensions in Preschool Practice. *Early Child Dev. Care* **2006**, *176*, 47–65. [CrossRef]
4. Fisher, K.; Hirsh-Pasek, K.; Golinkoff, R.; Singer, D.; Berk, L. Playing Around in School—Implications for Learning and Educational Policy. In *The Oxford Handbook of the Development of Play*; Pellegrini, A.D., Ed.; Oxford University Press: Oxford, NY, USA, 2011; pp. 341–360.

5. Toub, S.T.; Rajan, V.; Michnick Golinkoff, R.; Hirsh-Pasek, K. Guided Play—A Solution to the Play Versus Learning Dichotomy. In *Evolutionary Perspectives on Child Development and Education*; Geary, C.G., Berch, D.B., Eds.; Springer: Basel, Switzerland, 2016; pp. 117–141.
6. Edelmann, D.; Wannack, E.; Schneider, H. *Die Situation auf der Kindergartenstufe im Kanton Zürich. Eine Empirische Studie im Auftrag der Bildungsdirektion des Kanton Zürich*; Pädagogische Hochschule Bern: Bern, Switzerland; Pädagogische Hochschule Zürich: Bern, Zürich, Switzerland, 2018; Available online: https://www.phbern.ch/sites/default/files/2019-11/studie_situation-auf-der-kindergartenstufe.pdf (accessed on 12 February 2022).
7. Stamm, M. *Lasst die Kinder Los—Warum Entspannte Erziehung Lebenstüchtig Macht*; Piper: München, Berlin, Germany; Zürich, Switzerland, 2016.
8. Hattie, J.A.C.; Beywl, W.; Zierer, K. *Lernen Sichtbar Machen für Lehrpersonen—Überarbeitete Deutschsprachige Ausgabe von <Visible Learnings for Teachers>*; Schneider Verlag Hohengehren: Baltmannsweiler, Germany, 2014.
9. Hauser, B. Wirksamkeit spielbasierter Lernumgebungen—Empirische Befunde. In *Spielen und Lernen Verbinden—Mit Spielbasierten Lernumgebungen*; Kübler, M., Buhl, G., Rüdisüli, C., Eds.; Hep: Bern, Switzerland, 2020; pp. 41–50.
10. Pyle, A. Negotiating a Holistic View on Play—A Commentary. In *Play-Based Learning*; Pyle, A., Ed.; Encyclopedia on Early Childhood Development: Toronto, ON, Canada, 2018; pp. 60–65. Available online: https://www.child-encyclopedia.com/pdf/complet/play-based-learning (accessed on 2 February 2022).
11. Bulunuz, M. Teaching Science Through Play in Kindergarten—Does Integrated Play and Science Instruction Build Understanding? *Eur. Early Child. Educ. Res. J.* **2013**, *21*, 226–249. [CrossRef]
12. Hauser, B. *Spielen—Frühes Lernen in Familie, Krippe und Kindergarten*, 2nd ed.; Kohlhammer: Stuttgart, Germany, 2016.
13. Alfieri, L.; Brooks, P.J.; Aldrich, N.J.; Tenenbaum, H. Does Discovery-Based Instruction Enhance Learning? *J. Educ. Psychol.* **2011**, *103*, 1–18. [CrossRef]
14. Mayer, R.E. Should There Be a Three-Strikes Rule Against Pure Discovery Learning? The Case for Guided Methods of Instruction. *Am. Psychol.* **2004**, *59*, 14–19. [CrossRef] [PubMed]
15. Weisberg, D.S.; Zosh, J.M. How Guided Play Promotes Early Childhood Learning. In *Play-Based Learning*; Pyle, A., Ed.; Encyclopedia on Early Childhood Development: Toronto, ON, Canada, 2018; pp. 31–35. Available online: https://www.child-encyclopedia.com/pdf/complet/play-based-learning (accessed on 2 February 2022).
16. Hirsh-Pasek, K.; Golinkoff, R.; Berk, L.; Singer, D. *A Mandate for Playful Learning in Preschool: Presenting the Evidence*; Oxford University Press: Oxford, UK, 2008.
17. Berk, L.E.; Winsler, A. *Scaffoldings Children's Learning: Vygotsky and Early Childhood Education*; National Association for the Education of Young Children: Washington, DC, USA, 1995.
18. Kalcsics, K.; Wilhelm, M. *Lernwelten Natur, Mensch, Gesellschaft—Studienbuch*; Schulverlag Plus: Bern, Switzerland, 2017.
19. Zosh, J.; Hirsh-Pasek, K.; Hopkins, E.; Jensen, H.; Liu, C.; Neale, D.S.; Lynneth Solis, L.; Whitebread, D. Accessing the Inaccessible: Redefining Play as a Spectrum. *Front. Psychol.* **2018**, *9*, 1124. [CrossRef] [PubMed]
20. Deci, E.L.; Ryan, R.M. *Intrinsic Motivation and Self-Determination in Human Behavior*; Plenum Press: New York, NY, USA, 1985.
21. Trawich-Smith, J.T.; Wolff, J.; Koschel, M.; Vallarelli, J. Which Toys Promote High-Quality Play? Reflections on the Five-Year Anniversary of the TIMPANI Study. *Young Child.* **2014**, *69*, 40–49.
22. Vogt, F. Spielbegleitung. In *Spielen und Lernen Verbinden—Mit Spielbasierten Lernumgebungen*; Kübler, M., Buhl, G., Rüdisüli, C., Eds.; Hep: Bern, Switzerland, 2020; pp. 51–63.
23. Arnaldi, U.; Schütz, A.; Wannack, E. Die Spiel-und Lernbegleitung im Kindergarten. In *4bis8 Fachzeitschrift für Kindergarten und Unterstufe. Die Bedeutung des Freien Spiels in der Kindergartendidaktik*; Wannack, E., Arnaldi, U., Schütz, A., Eds.; Schulverlag Plus: Bern, Switzerland, 2010; pp. 10–12.
24. Siry, C. Exploring the Complexities of Children's Inquiries in Science: Knowledge Production Through Participatory Practices. *Res. Sci. Educ.* **2013**, *42*, 2407–2430. [CrossRef]
25. Adbo, K.; Carulla, C.V. Learning About Science in Preschool: Play-Based Activities to Support Children's Understanding of Chemistry Concepts. *Int. J. Early Child.* **2020**, *52*, 17–35. [CrossRef]
26. Glauser-Ismail, N. *je-desto: Kompetenzförderung im Freispiel. Spielgestaltung und Spielbegleitung am Beispiel MINT*; Bern, Switzerland. 2018. Available online: https://www.je-desto.ch (accessed on 12 February 2022).
27. Textor, M.R. *Spiel und Spielförderung*; Würzburg, Germany. 2004. Available online: https://www.kindergartenpaedagogik.de/images/PDF/2278.pdf (accessed on 12 February 2022).
28. Stamm, M. *Frühförderung als Kinderspiel. Ein Plädoyer für das Recht der Kinder auf das Spiel*; SWISS Education: Bern, Switzerland, 2014; Available online: https://www.margritstamm.ch/images/Dossier_Spiel%20def.pdf (accessed on 12 February 2022).
29. UNICEF. *Convention on the Rights of the Child*; UNICEF: New York, NY, USA, 2019; Available online: https://www.unicef.org/child-rights-convention/convention-text (accessed on 27 February 2022).
30. Farneti, A. *Elementi di Psicologia Dello Sviluppo*, 9th ed.; Carocci: Rome, Italy, 2008.
31. Einsiedler, W. *Das Spiel der Kinder*; Klinkhardt: Bad Heilbrunn, Germany, 1999.
32. Freud, S. Das Unbehagen der Kultur. In *Gesammelte Werke Band XIV.*; Freud, S., Ed.; Fischer: Frankfurt, Germany, 1930; pp. 419–506.
33. Pellegrini, A.D. *The Role of Play in Human Development*; Oxford University Press: New York, NY, USA, 2009.

34. Burghardt, G.M. Defining and Recognizing Play. In *Oxford Handbook of the Development of Play*; Pellegrini, A.D., Ed.; Oxford University Press: New York, NY, USA, 2011; pp. 9–18.
35. Howard, J.; Jenvey, V.; Hill, C. Children's Categorization of Play and Learning Based on Social Context. *Early Child Dev. Care* **2006**, *176*, 379–393. [CrossRef]
36. Erikson, E.M. *Kinderspiel und Politische Phantasie*; Suhrkamp: Frankfurt, Germany, 1978.
37. Schousbue, I.; Winther-Lindqvist, D. Children's Play and Development. In *Children's Play and Development. Cultural-Historical Perspectives*; Schousbue, I., Winther-Lindqvist, D., Eds.; Springer: Dordrecht, The Netherlands, 2013; pp. 1–12.
38. Piaget, J. *Nachahmung, Spiel und Traum*; Klett: Stuttgart, Germany, 1969.
39. Bringuier, J.C.; Piaget, J. *Im Allgemeinen Werde ich Falsch Verstanden. Unterhaltungen*; Europäische Verlagsanstalt: Hamburg, Germany, 1996.
40. Oerter, R. Zur Psychologie des Spiels. *Psychol. Ges.* **2007**, *31*, 7–32.
41. Vygotsky, L.S. Das Spiel und seine Bedeutung in der psychischen Entwicklung des Kindes. In *Psychologie des Spiels*; Elkonin, D.L., Ed.; Pahl-Rugenstein: Köln, Germany, 1980; pp. 430–465.
42. Vygotsky, L.S. *Ausgewählte Schriften. Arbeiten zur Psychischen Entwicklung und Persönlichkeit*; Volk und Wissen: Berlin, Germany, 1987.
43. Vygotsky, L.S. *Mind and Society*; Harvard University Press: Cambridge, MA, USA, 1978.
44. Rossen, L.H. Play to Learn, Learn to Play: Boundary Crossing Within Zones of Proximal Development. In *Children's Play and Development. Cultural-Historical Perspectives*; Schousbue, I., Winther-Lindqvist, D., Eds.; Springer: Dordrecht, The Netherlands, 2013; pp. 141–164.
45. Leontjew, A.N. *Tätigkeit, Bewusstsein, Persönlichkeit*; Klett-Cotta: Stuttgart, Germany, 1977.
46. Freud, S. Erinnern, Wiederholen, Durcharbeiten. In *Zur Dynamik der Übertragung. Behandlungstechnische Schriften*; Freud, S., Ed.; Fischer: Frankfurt, Germany, 1920; pp. 85–96.
47. Göncü, A.; Gaskins, S. *Play and Development. Evolutionary, Sociocultural and Functionals Perspectives*; Lawrence Erlbaum Associates: New York, NY, USA, 2007.
48. Vygotsky, L.S. The Development of Scientific Concepts in Childhood. In *The Collected Works of L. S. Vygotsky*; Rieber, R.W., Carton, A.S., Eds.; Springer: Dordrecht, The Netherlands, 1987; pp. 167–241.
49. Carey, S. *Conceptual Chance in Childhood*; The MIT: Cambridge, UK, 1985.
50. Vosniadou, S.; Brewer, W.F. Mental Models of the Earth. A Study of Conceptual Change in Childhood. *Cogn. Psychol.* **1992**, *24*, 535–585. [CrossRef]
51. Möller, K. Lernen von Naturwissenschaften heisst Konzepte verändern. In *Fachdidaktik Naturwissenschaft. 1.-9. Schuljahr*; Labudde, P., Ed.; Haupt: Bern, Switzerland, 2010.
52. Posner, G.J.; Strike, K.A.; Hewson, P.W.; Gertzog, W.A. Accomodation of a Scientific Conception: Towards a Theory of Conceptual Change. *Sci. Educ.* **1982**, *66*, 211–227. [CrossRef]
53. Vosnidou, S. The Conceptual Change Approach and Its Re-fRaming. In *Reframing the Conceptual Change Approach in Learning and Instruction*; Vosniadou, S., Baltas, A., Vamvakoussi, X., Eds.; Elsevier: Amsterdam, The Netherlands, 2007; pp. 1–15.
54. Hardy, I.; Ionen, A.; Möller, K.; Stern, E. Effects of Instructional Support Within Constructivist Learning Environments for Elementary School Students' Understanding of Floating and Sinking. *J. Educ. Psychol.* **2006**, *98*, 307–326. [CrossRef]
55. Treagust, D.; Duit, R. Compatibility Between Cultural Studies and Conceptual Change in Science Education: There is More To Acknowledge Than to Fight Stras Men! *Cult. Stud. Sci. Educ.* **2008**, *3*, 387–395. [CrossRef]
56. Vygotsky, L.S. Thinking and Speech. In *The Collected Works of L. S. Vygotsky, Volume 1: Problems of General Psychology*; Rieber, R.W., Carton, A.S., Eds.; Plenum: New York, NY, USA, 1987.
57. Ferreira Alves, P. Vygotsky and Piaget: Scientific Concepts. *Psychol. Russ. State Art* **2014**, *7*, 3. [CrossRef]
58. Shepardson, D.P.; Britsch, S. Mediating Meaning in the Social World of the Science Classroom. *Electron. J. Sci. Educ.* **2015**, *19*, 1–13.
59. Gomes, J.; Fleer, M. Is Science Really Everywhere? Teachers' Perspectives on Science Learning Possibilities in the Preschool Environment. *Res. Sci. Educ.* **2020**, *50*, 1961–1989. [CrossRef]
60. Lohaus, A.; Vierhaus, M. Kognition. In *Entwicklungspsychologie des Kindes und Jugendalters für Bachelor*, 3rd ed.; Lohaus, A., Vierhaus, M., Eds.; Springer: Berlin/Heidelberg, Germany, 2015; pp. 116–130.
61. Sodian, B. Entwicklung des Denkens. In *Entwicklungspsychologie*, 6th ed.; Oerter, R., Montada, L., Eds.; Beltz: Weinheim, Germany, 2008; pp. 436–479.
62. Lück, G. *Handbuch der naturwissenschaftlichen Bildung: Theorie und Praxis für die Arbeit in Kindertageseinrichtungen*; Herder: Freiburg im Breisgau, Germany, 2018.
63. Sodian, B. Die Entwicklung des Denkens. Vom Vorschul- zum Grundschulalter. *Theor. und Prax. der Soz.* **2004**, *112*, 12–16.
64. Singer, J.A.; Kohn, A.S.; Resnick, L.B. Knowing About Proportions in Different Contexts. In *Learning and Teaching Mathematics: An International Perspective*; Nunes, T., Bryant, P., Eds.; Psychology Press: Hove, UK, 1997; pp. 115–132.
65. Stavy, R.; Tirosh, D. *How Students (Mis-)Understand Science and Mathematics—Intuitive Rules*; Teacher College Press: Columbia, SC, USA, 2000.
66. Möller, K.; Steffensky, M. Naturwissenschaftliches Lernen im Unterricht mit vier- bis achtjährigen Kindern. In *Didaktik für die Ersten Bildungsjahre—Unterricht Mit 4-Bis 8-Jährigen Kindern*; Leuchter, M., Ed.; Friedrich: Seelze, Germany, 2010; pp. 163–178.
67. Soostmeyer, M. *Problemorientiertes Lernen im Sachunterricht*; UTB: Paderborn, Germany, 1987.

68. Labudde, P.; Adamina, M. *Kompetenzen Fördern—Standards Setzen: Naturwissenschaftliche Bildung in der Primarstufe. Handreichung des Programms Sinus and Grundschulen*; IPN: Kiel, Germany, 2012.
69. DeLuca, C. Assessment in Play-Based Learning. In *Play-Based Learning*; Pyle, A., Ed.; Encyclopedia on Early Childhood Development: Toronto, ON, Canada, 2018; pp. 36–41. Available online: https://www.child-encyclopedia.com/pdf/complet/play-based-learning (accessed on 2 February 2022).
70. Erziehungsdirektion des Kanton Berns (Ed.) *Lehrplan 21—Fachbereichslehrplan Natur, Mensch, Gesellschaft*; Gassmann Print: Biel/Bienne, Switzerland, 2016.
71. Pahl, A.; Tschiesner, R.; Adamina, M. The 'Nature-Human-Society'-Questionnaire for Kindergarten and Primary School Trainee Teachers: Psychometric Properties and Validation. *ICERI Proc.* **2019**, *12*, 3196–3205. [CrossRef]
72. Tschiesner, R.; Pahl, A. Trainee Teachers' Preferences in the Subject 'Human-Nature-Society': The Role of Knowledge. *ICERI Proc.* **2019**, *12*, 3167–3176. [CrossRef]
73. Pahl, A.; Tschiesner, R. What Influences Attitudes and Confidence in Teaching Physics and Technology Topics? An Investigation in Kindergarten and Primary-School Trainee Teachers. *Sustainability* **2022**, *14*, 87. [CrossRef]
74. Pahl, A. Teaching Physics in Kindergarten and Primary School—What do Trainee Teachers Think of This? In *Physics Teacher Education—What Matters*; Marks, J.B., Galea, P., Gatt, S., Sands, D., Eds.; Springer: Berlin/Heidelberg, Germany, 2022; in press.
75. Miller, E.; Allmon, J. *Crisis in Kindergarten: Why Children Need to Play in School*; Alliance for Childhood: College Park, MD, USA, 2009.
76. Bergen, D. Cognitive Development in Play-Based Learning. In *Play-Based Learning*; Pyle, A., Ed.; Encyclopedia on Early Childhood Development: Toronto, ON, Canada, 2018; pp. 26–30. Available online: https://www.child-encyclopedia.com/pdf/complet/play-based-learning (accessed on 2 February 2022).
77. Edwards, K.; Loveridge, J. The Inside Story: Looking Into Early Childhood Teachers' Support of Children's Scientific Learning. *Australas. J. Early Child.* **2011**, *36*, 28–35. [CrossRef]
78. Lieger, C.; Weidinger, W. *Spielen Plus. Ein Handbuch für Kindergarten, Schule und Betreuung*; Hep: Bern, Switzerland, 2021.
79. Tunnicliffe, S.D.; Gkouskou, E. Science in Action in Spontaneous Preschool Play—An Essential Foundation for Future Understanding. *Early Child. Dev. Care* **2018**, *190*, 54–63. [CrossRef]
80. Fleer, M. Understanding the Dialectical Relations Between Everyday Concepts and Scientific Concepts Within Play-Based Programs. *Res. Sci. Educ.* **2009**, *39*, 281–306. [CrossRef]
81. Larson, J. Children's Encounters with Friction As Understood As a Phenomenon of Emerging Science and As Opportunities for Learning. *J. Res. Child. Educ.* **2013**, *27*, 377–392. [CrossRef]
82. Pramling Samuelsson, I.; Asplund Carlsson, M. The Playing Learning Child: Towards a Pedagogy of Early Childhood. *Scand. J. Educ. Res.* **2008**, *52*, 623–641. [CrossRef]
83. Sligoris, M.; Almeida, S.C. Young Children's Development of Scientific Knowledge Through the Combination of Teacher-Guided Play and Child-Guided Play. *Res. Sci. Educ.* **2019**, *49*, 1569–1593. [CrossRef]
84. Fleer, M. Scientific Playworlds: A Model of Teaching Science in Play-Based Settings. *Res. Sci. Educ.* **2019**, *49*, 1257–1278. [CrossRef]
85. Fleer, M.; Fragkiadiaki, G.; Rai, P. The Place of Theoretical Thinking in Professional Development: Bringing Science Concepts Into Play Practice. *Learn. Cult. Soc. Interact.* **2022**, *32*, 100591. [CrossRef]
86. Hadzigeorgiou, Y. The Role of Wonder and 'Romance' in Early Childhood Science Education. *Int. J. Early Years Educ.* **2001**, *9*, 63–69.
87. Mogel, H. *Psychologie des Kinderspiels. Von den Frühsten Spielen bis zum Computerspiel*, 3rd ed.; Springer: Berlin/Heidelberg, Germany, 2008.
88. Neutert, N. Spielen ist ein ernster Fall. *Hambuger Morgenpost* **1971**, *77*, 4.
89. Hattie, J.A.C. *Visible Learning—A Synthesis of over 800 Meta-Analyses Relating to Achievement*; Routledge: London, UK, 2009.
90. Scheiblauer, M. *Lobpreisung der Musik. Blätter für Musikerziehung und Allgemeine Erziehung*; Sämann: Zürich, Switzerland, 1951.
91. Makino, H.; Hwang, E.J.; Hedrick, N.G.; Komiyama, T. Circuit Mechanisms of Sensorimotor Learning. *Neuron* **2016**, *92*, 705–721. [CrossRef] [PubMed]
92. Hajos, A. *Wahrnehmungspsychologie. Psychophysik und Wahrnehmungsforschung*; Kohlhammer: Stuttgart, Germany, 1972.
93. Katzenberger, L. Perzeption. In *Pädagogisches Lexikon*; Horney, W., Ruppert, J.P., Schulze, W., Eds.; Bertelsmann: Gütersloh, Germany, 1970.
94. Bak, P.M. *Wahrnehmung, Gedächtnis, Sprache, Denken*; Springer: Berlin/Heidelberg, Germany, 2020.
95. Halliday, M. Towards a Language-Based Theory of Learning. *Linguist. Educ.* **1993**, *5*, 93–116. [CrossRef]
96. Merz, V. Vom Greifen zum Begriff. *Religion Lebenskunde* **2003**, *3*, 16–18.
97. Neugebauer, C.; Nodari, C. *Förderung der Schulsprache in Allen Fächern. Praxisvorschläge für Schulen in Einem Mehrsprachigen Umfeld. Kindergarten bis Sekundarstufe I*; Schulverlag Plus: Bern, Switzerland, 2012.
98. Leisen, J. *Handbuch Sprachförderung im Fach. Sprachsensibler Fachunterricht in der Praxis*; Klett: Stuttgart, Germany, 2013.
99. Leisen, J. Richtige, reichhaltige und flüssige Sprache entwickeln. *Unterr. Phys.* **2005**, *16*, 21–25.
100. Vogt, F.; Löffler, C.; Haid, A.; Itel, N.; Schönfelder, M.; Zumwakel, B.; Reichmann, E. Sprachförderung im Alltag: Umsetzung im Kindergarten, Kita und Spielgruppe. Videobasierte Fallanalysen. *Schweiz. Zeitschrift Bild.* **2015**, *37*, 93–111. [CrossRef]
101. Crystal, D. *A First Dictionary of Linguistics and Phonetics*; Press Boulder: Westview Colorado, CO, USA, 1980.
102. Chomsky, N. *Reflexionen über die Sprache*; Suhrkamp: Frankfurt, Germany, 1977.

103. Anderson, J.R.; Bower, G.H. A Propositional Theory of Recognition. *Mem. Cogn.* **1974**, *2*, 406–412. [CrossRef]
104. Bildungs-und Kulturdirektion des Kanton Berns (BKD). *Fächernet Volkschule*; BKD: Bern, Switzerland; Available online: https://www.faechernet.bkd.be.ch/de/start/uebergeordnete-themen/1-zyklus-spezifisches.html (accessed on 12 February 2022).
105. Adamina, M. Weite Felder und Nischen—Fachdidaktik im Zusammenspiel von Forschung, Entwicklung, Lehre, und Schulpraxis (mit besonderem Blick auf die Primarstufe). In *Stand der Fachdidaktiken in der Schweiz*; Schweizerische Konferenz der Rektrorinnen und Rektoren der Pädagogischen Hochschulen (COHEP), Ed.; Switzerland; 2013; pp. 28–29. Available online: https://www.swissuniversities.ch/fileadmin/swissuniversities/Dokumente/Kammern/Kammer_PH/Dokumente_Berichte/130514_Onlinedokumentation.pdf (accessed on 2 February 2022).