# PEDAGOGIC APPROACH

## OF THE “HAUS DER KLEINEN FORSCHER” FOUNDATION

### A GUIDE TO FACILITATING LEARNING IN SCIENCE, MATHEMATICS, AND TECHNOLOGY

5TH EDITION

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Helmholtz-Gemeinschaft Siemens Stiftung Dietmar Hopp Stiftung Deutsche Telekom Stiftung Autostadt GmbH

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*„A child is not a vase to be filled, but a fire to be lit.“*

François Rabelais

# The "Haus der kleinen Forscher" Foundation – More educational opportunities for all

Science, mathematics, and technology shape our everyday lives and are developing at a rapid pace. Our society must therefore give all its citizens the opportunity to continuously develop their science, mathematics, and technology skills, thereby enabling them to make independent decisions in these areas.

Against this background, the "Haus der kleinen Forscher" Foundation (Little Scientists' House Foundation) has set itself an ambitious objective – namely, to enable all children between the ages of three and ten in Germany to have everyday encounters with science, mathematics, and technology topics. Through the Foundation's work, these girls and boys have the opportunity to discover these exciting fields for themselves at an early stage and in an enjoyable way.

Through its professional development programme, the Foundation supports early childhood educators and primary school teachers in accompanying children in their exploration, inquiry, and learning activities. Moreover, by providing pedagogical resources specifically designed for children between the ages of six and ten, we encourage primary school children to engage in self-directed scientific inquiry.

With its pedagogic approach, the "Haus der kleinen Forscher" Foundation takes children seriously – as competent, actively learning, inquisitive, and outward-looking individuals. The experiential world and competencies form the basis of resource-oriented and developmentally appropriate support. Engagement with natural phenomena and mathematical and technical problems fosters children's inquisitiveness, their joy of learning and thinking, and their language, social, and motor skills; they experience a sense of self-efficacy and self-confidence; they feel recognised and strong. It is therefore our aim to ensure that all children in this country are given the opportunity to discover their own talents and aptitudes in science, mathematics, and technology. They can develop and consolidate these talents and aptitudes as they proceed along their educational path to their career choice.

The development of the Foundation's professional development programme and pedagogical resources is oriented towards the content and specifications of the education plans and curricula of the federal states (*Länder*) and is informed by current findings in developmental psychology, learning research, early childhood education, and subject-specific didactics. Moreover, it also draws on a wealth of practical experience and substantive suggestions gathered at the seminars for the trainers who deliver our professional development workshops; during regular visits to early childhood education and care centres, after-school centres, and primary schools; and within the framework of training observations in the Foundation's local networks.

The "Haus der kleinen Forscher" Foundation is the largest early childhood education programme in Germany. Since 2011, it also targets early childhood educators at after-school centres and primary school teachers. The Foundation's partners are the Helmholtz Association, the Siemens Stiftung, the Dietmar Hopp Stiftung, the Deutsche Telekom Stiftung, and the Autostadt in Wolfsburg; it is supported by the Federal Ministry of Education and Research.



# Foreword

## Dear teachers and educators,

I am delighted that you have taken the opportunity to participate in one of our professional development workshops, and I warmly welcome you to the "Haus der kleinen Forscher" programme.

Please join us on our journey through the exciting areas of science, mathematics, and technology education, which I am pleased to say have been an integral part of the work of early childhood education and care centres, after-school centres, and primary schools for some years now.[1] They offer children the possibility of pursuing many exciting questions about things they encounter in their experiential world. This fosters both their joy of exploring and investigating and their ability to tackle problems and questions. And this in turn strengthens their personalities and togetherness.

Perhaps you're approaching this "new" field for the first time; or perhaps scientific inquiry activities have already been, or are being, eagerly conducted at your institution. Here at the "Haus der kleinen Forscher" Foundation, we ourselves continue to explore and investigate not only new and traditional science, mathematics, and technology topics but also the best ways to accompany children in their exploration and inquiry activities. I am myself aware of the challenges involved in putting new scientific knowledge into practice, and I am happy that we, the "Haus der kleinen Forscher" Foundation, can accompany you in this process. We would like to support you with our pedagogical resources, brochures, and ideas.

The present brochure is divided into three parts. In Part A, we invite you to turn your attention to the current state of research in developmental psychology; in Part B, we outline the pedagogic approach of the "Haus der kleinen Forscher" Foundation; and in Part C, we use a concrete example from the topic area "water" to demonstrate how you can implement this pedagogic approach to science, mathematics, and technology education in your everyday activities with the children.

We welcome suggestions, criticism, and praise. Please e-mail, fax, or write to us, take part in our regular surveys, or simply give us a call.

I wish you lots of enjoyment and success in your joint exploration and inquiry activities with the children!

Michael Fritz
Chairman of the Executive Board of
the "Haus der kleinen Forscher" Foundation

[1] In what follows, educational institutions that cater for children between the ages of three and six (e.g., kindergartens, *Kinderläden*) are collectively referred to as "early childhood education and care centres"; half- and all-day primary schools, after-school centres, and extracurricular offerings are collectively referred to as "after-school centres and primary schools"; and early childhood educators and primary school teachers are collectively referred to as "teachers and educators".

PART A

# How do children learn?



## Education in science, mathematics, and technology for children between the ages of three and ten

Children spend a significant portion of their lives at early childhood education and care centres and, later, at schools and after-school centres. By now, early childhood education and care centres and after-school centres are recognised as educational institutions in which education in science, mathematics, and technology has assumed great importance.[2] It is now firmly anchored in the education plans and curricula of all German federal states (*Länder*). The methods, priorities, and objectives of early childhood education are diverse.[3] It is evident that, from the very beginning, the exploration of their surroundings – and thus also the exploration of science, mathematics, and technology – is part of children's exploration of their world.[4]

From the start, children are inquisitive and focused. Equipped with prior experiences, they are in search of meanings, interrelationships, and ideas about how the world works.[5] At first, they learn unconsciously through movement and play; they do not compartmentalise their learning into specific subject areas.[6] In the self-learning process – especially that of younger children – learning language and movement cannot, for example, be separated from experiencing the natural world or from creativity.[7] Only later do verbalisation and conscious learning come about.[8] Secure bonds[9] and good social relationships both in the family and at early childhood education and care centres, primary schools, and after-school centres, form the basis of the entire learning process.[10] On this basis, early childhood educators and primary school teachers can allow children to engage in exploration and can introduce science, mathematics, and technology topics into their everyday lives.[11] Experience of the natural world is essential for children's development, on the one hand,[12] and for the development of their consciousness of self as part of a protective environment, on the other.[13] In this way, the world becomes an interesting place and an exciting challenge. It is important that children enjoy learning from the very beginning because childhood is the most intensive phase in every person's process of lifelong learning.[14]

Because science, mathematics, and technology have a formative influence on our daily lives and are developing at a rapid pace, it is essential for participation in our science- and technology-driven society that all children be given the chance to acquire education in these fields.[15] The most important objective of these education processes is to ensure that children develop, or maintain, their inquisitiveness and a positive attitude. The aim is to give them the opportunity to pursue their own questions in an inquiry-based way. For this, they need interested adults who can facilitate their inquiry activities in an age-appropriate manner. With its professional development programme and pedagogical resources, the "Haus der kleinen Forscher" Foundation supports teachers and educators at primary schools, after-school centres, and early childhood education and care centres in fostering a spirit of inquiry in children between the ages of three and ten in a qualified way.

2 Cf. OECD (2012); Nölke, C. (2013: 2)
3 Cf. Ansari, F. (2013); Fischer, H.-J. (2013: 29); Hiller, S. (2012: 162); Plappert, D. (2013: 71ff.)
4 Cf. Möller, K. & M. Steffensky (2010: 164); Nölke, C. (2013: 2); Shonkoff, J. P. (2004)
5 Cf. Schäfer, G. E. (2001: 7); Pahnke J. & S. Pauen (2012)
6 Cf. Fischer, H.-J. (2013: 20, 24); Schäfer, G. E. (2014: 34)
7 Cf. Largo, R. H. (2010: 76); Zimmer, R. (2013)
8 Cf. Fischer, H.-J. (2013: 24); Plappert, D. (2013: 80); Schäfer, G. E. (2014: 34, 232)
9 Cf. Bowlby, J. (1969)
10 Cf. Ahnert, L. (2004) und (2007)
11 Cf. Pianta, R. (1999)
12 Cf. Gebhardt, U. (2013: 36); Louv, R. (2011: 79); Weber. A (2011)
13 Cf. Gebhardt, U. (2013: 252); Hüther, G. & H. Renz-Polster (2013: 227)
14 Cf. Kiefer, M., Schuck, S., Schenk W., & K. Fiedler (2007)
15 Cf. Pahnke, J. & P. Rösner (2012)

# Developmental foundations of learning

How children learn and develop cognitively is a question that occupies the minds of many teachers and educators. Great progress has been made in developmental psychology in recent years with regard to understanding cognitive development and learning processes in children. By now, researchers in this field know so much about learning that they are able to say quite precisely what, in practice, helps a child to develop and acquire knowledge.

***It is not just a question of knowledge about something but of the process by means of which one arrives at that knowledge.***

But what should we understand education in science, mathematics, and technology at early childhood education and care centres, primary schools, and after-school centres to mean in the first place? The main priority of the "Haus der kleinen Forscher" Foundation is to promote the joy of learning and the development of problem-solving skills. The Foundation's offerings are aimed at accompanying children in a process of exploration, inquiry, and knowledge acquisition that is oriented towards the approach adopted in the natural sciences (see Part C "Investigating together – The Inquiry Cycle").

EXAMPLE

*In winter, the children discover a ball that got left behind in the bushes and bring it into the warm house. Because the ball does not seem to have enough air in it, the children decide to pump it up. However, by the time they find the air pump, the ball has become firmer again all by itself. The children are fascinated by this, and they ask themselves why it happened. To find the answer, they first collect* ***assumptions*** *as to why the ball became firmer again (e.g., that there is a difference between outdoors and indoors). They can easily test their own assumptions by engaging in* ***inquiry activities*** *(e.g., by putting the ball in a cold place again, waiting for a while, and then examining how firm it feels). The children discover that it makes a difference whether the ball is lying in a warm room or outdoors in the cold. This may give rise to further questions (e.g., whether the ball gets even firmer if it is placed on a radiator). The investigation of this and other questions leads the children to the* ***conclusion*** *that temperature plays a role and that in a warm place the air inside the ball takes up more space than in a cold place.*

In the above example, why the air warms up and expands is not really that important. What is important – and exciting – first of all, is that it does. For the process of constructing scientific knowledge, the main determining factor is the path that the children follow to gain knowledge and the way in which they are accompanied during this process.

## Are children capable of scientific reasoning?

Research findings from contemporary developmental psychology reveal that some important component skills of scientific reasoning and action develop at a very early age. Children between the ages of three and six are already capable of key aspects of inquiry behaviour: they can make assumptions, test them, and draw initial conclusions from their findings. Primary school students are capable of systematic exploration and inquiry – provided they are familiarised with this systematic approach by a facilitator of learning. They are then capable of making an informed choice between different methods of inquiry and they are also able to give reasons for their decisions and their findings. In Part C of the present brochure, we provide suggestions for suitable prompts to encourage children to adopt a systematic approach to exploration and inquiry.

NOTE

*As time goes by, children between the ages of three and six develop the ability to think about their own thinking. This process is known as metacognition. Between the ages of six and ten, children make great progress in reflecting on their learning processes and discussing them with others. Moreover, the development of metacognitive skills is particularly enhanced when early childhood educators talk to the children about their learning process on a regular basis.*

The learning processes aspired to at early childhood education and care centres differ from those at after-school centres and primary schools in terms of the depth of understanding they achieve. What is crucial in the case of children between the ages of three and six is that they have initial basic experiences with natural phenomena and mathematical and technical questions and that they learn to formulate simple statements of relationships between variables ("If A, then B". "The more A, the more B".). In other words, it is a question of recognising correlations and conditions. In early childhood education and care centres, children can, for example, investigate which objects float in water and which objects sink. Later, between the ages of six and ten, the children can build on this knowledge and investigate individual factors in more depth – for example, by systematically comparing and correlating the weight, size, and immersion depth of floating objects.

The continuity of the education chain is of great importance for the sustainable anchoring of knowledge. The "Haus der kleinen Forscher" Foundation therefore takes great care to ensure that its pedagogical resources and other offerings are mutually consistent.

## Findings from developmental psychology [16]

Even infants have scientific reasoning skills. Studies show that six-month-old infants already reflect on the cause and effect of sequences of events. Moreover, babies have a specific stock of innate knowledge – so-called core knowledge – in various domains, such as physics, mathematics, psychology, and language. For example, they know that inanimate objects change their position only if an external force is acting on them whereas animate objects can move themselves. Children’s core knowledge constitutes the starting point for further learning.

Toddlers can understand causal if-then principles and begin to apply them in their thinking and actions. They search for causes and show initial insights into connections between events – for example, the domino chain reaction that produces an interesting effect towards the end. From the beginning, toddlers embed their knowledge in naive theories about natural phenomena. They already have substantive knowledge in the biological and physical domains that is similar in many respects to that of adults. Moreover, their recognition memory is already well developed.

Children between the ages of three and six fulfil key cognitive prerequisites for scientific reasoning. They are able to understand basic connections between cause and effect and apply this understanding of causality correctly when they reflect on events (e.g., when they try to find out what determines whether or not a cake will rise). They can recognize false beliefs when they compare presumptions and assumptions with actual observations. Moreover, children in this age group become increasingly confident in their knowledge about their own knowledge (metacognition) – in other words, in knowing that, and how, they know something.

Children between the ages of six and ten have good language and memory skills and increasing cognitive flexibility. Because of their improved abstract thinking skills, they now find it progressively easier to mentally organise learning experiences and to establish and verbally express meaningful connections between objects, events, processes, etc. Children in this age group are increasingly able to structure and plan their cognitive processes and they begin to experiment systematically. By changing only one variable and keeping all the others constant, they are capable of examining with the help of the teacher or educator which condition (i.e. variable) is decisive for a result. Moreover, children of this age increasingly interact with peers. Self-awareness within the peer group is a decisive developmental step that leads to enhanced self-perception and self-efficacy.

**FURTHER READING**

*If you would like to find out more about the developmental prerequisites for education in science, mathematics and technology in children between the ages of three and ten, you will find four expert reports on the subject in Volume 4 of the series “Wissenschaftliche Studien zur Arbeit der Stiftung ‘Haus der kleinen Forscher’” [Scientific Studies on the Work of the “Haus der kleinen Forscher” Foundation; available only in German] (Stiftung “Haus der kleinen Forscher” [2012a]; also available as a downloadable PDF at www.haus-der-kleinen-forscher.de). See also Volumes 1 to 6 from the series “Natur-Wissen schaffen” (Fthenakis et al., 2008 to 2009).*

[16] Cf. Pauen, S. & J. Pahnke (2009); Oerter R. & L. Montada (Eds; 2008); Sander, E. (2011)

## How can children be supported in their development?

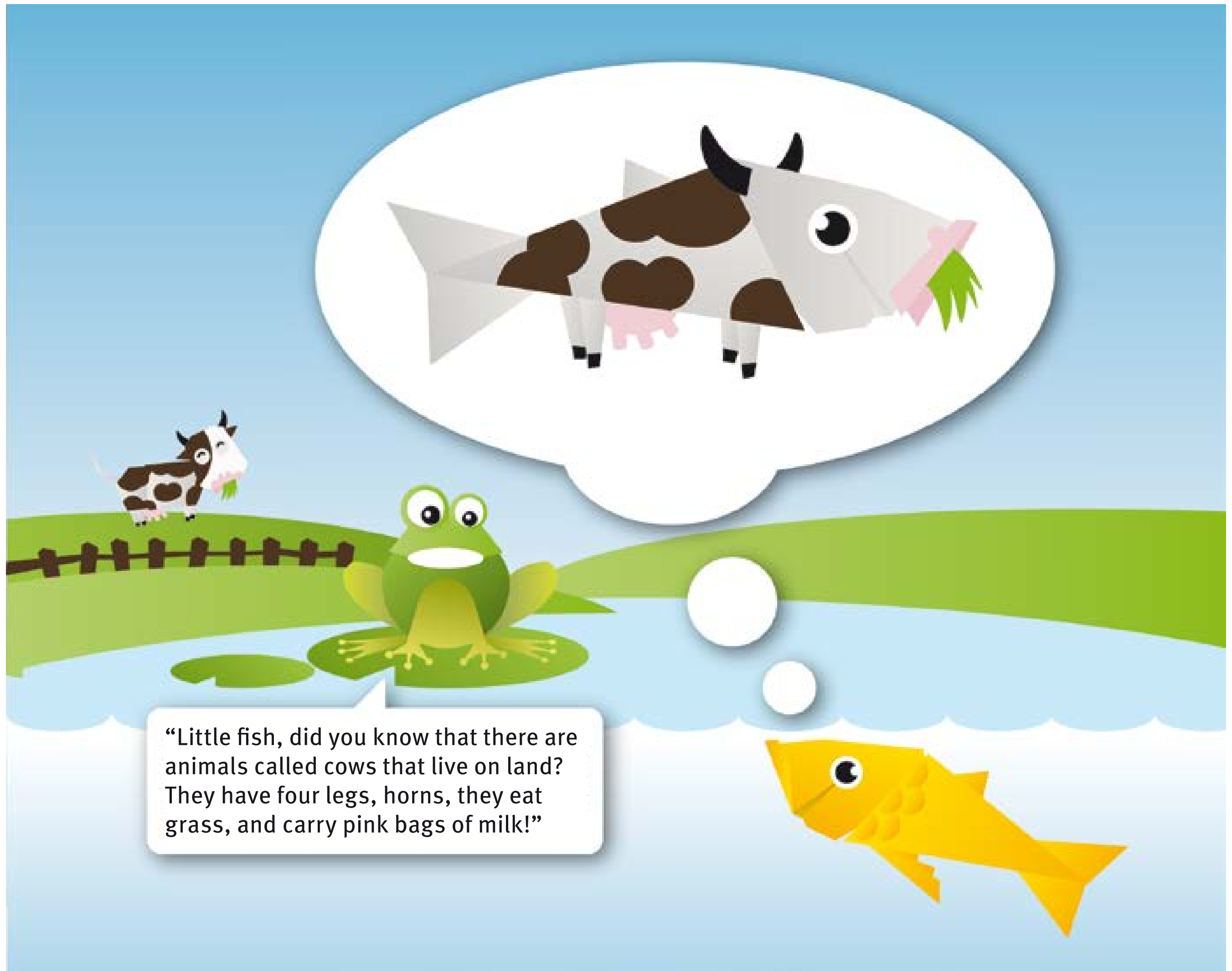
Children between the ages of three and ten already have considerable skills in inquiry-based thinking and knowledge of science, mathematics, and technology. At the same time, they are open-minded, inquisitive, and eager to learn more about the natural phenomena they experience in the world around them. Hence, the basic prerequisites for early educational stimulation are met, and in many cases early childhood educators and primary school teachers can build on children's prior basic knowledge and understanding. This is necessary because to enable it to be stored as lasting knowledge, new knowledge must build on prior knowledge.

In addition to age-typical knowledge, children have their own personal stock of prior knowledge. Hence, individual approaches are called for. Teachers and educators should therefore endeavour to help each child to have precisely those experiences that help him or her to grasp the world bit by bit.

It is important that children experience things for themselves in order to enable them to construct a mental model of the world from these experiences. As the story of the frog and the fish in Figure 1 shows, this mental model remains limited if it is constructed solely on the basis of hearsay rather than first-hand experience.

*Figure 1*

***The Story of the Frog and the Fish (based on an idea by Leo Lionni, 2005)***








The frog's story fascinates the little fish because up to now he has known only his own underwater world. The fish can picture in his mind what the frog tells him only by using his own prior experiences and building on them. In this way, his very own image of a fishcow forms in his mind. If the little fish were to meet the cow face to face one day, he would have new opportunities to learn through first-hand experience what a cow is.

Following the Russian educationalist Lev Vygotsky, a child's zone of proximal development can be defined as "the distance between the actual developmental level … and the level of potential development … under adult guidance or in collaboration with more capable peers" (see Figure 2).[17] In other words, this zone represents the entire range of development possibilities that a child can access with the support of a facilitator of learning. The task of the teacher or educator consists in recognising the potentially achievable (next) level of development and giving the child the necessary support to cross this zone.

*Figure 2*

***Zone of proximal development Based loosely on Lev Vygotsky***


[17] Cf. Vygotsky, L.S, "Interaction between Learning and Development" in Michael Cole et al. (Eds), L.S. Vygotsky: Mind in Society (1978: 86; ); the chapter is reprinted in Gauvain M. & M. Cole (1997: 29–36). Downloadable at http://www.psy.cmu.edu/~siegler/vygotsky78.pdf (accessed 11.08.2015)

NOTE

*Tasks of facilitators of learning:*
*Teachers and educators should identify the child's actual developmental level and the learning opportunities that will best enable him or her to take a further step forward independently.*

## Consequently, teachers and educators have the following concrete tasks:

**Always build on the children's prior knowledge**
Teachers and educators can gain an insight into children's prior experiences and thought processes by listening carefully to the children, observing them, and asking them about their own assumptions.

**Talk to the children**
By engaging in dialogue with the children, teachers and educators support them in taking the next step in their cognitive development. Rather than giving explanations, they should ask leading questions.

**Encourage the children to reflect**
When children use apparently false concepts – for example "the wind comes from the trees" – this reveals the way in which they explain a particular phenomenon to themselves at that point in time. The task here is to draw their attention at an opportune moment to the fact that wind also occurs in places where there are no trees. In this way, the teacher or educator prompts the children to develop a new theory themselves.

FURTHER READING

*If you would like to study children's thinking and learning processes in greater depth, you will find suggestions in the following books, for example: Ansari, S. (2009; Enderlein, O. (2001), Pauen, S. (2006); Pauen S. & J. Pahnke (2009).*



PART B

# Pedagogic approach of the “Haus der kleinen Forscher” Foundation



## Our image of the child

The pedagogic concept of the “Haus der kleinen Forscher” Foundation is based on a particular image of the child. This image is the basis for pedagogic action and reflects our own conceptualisation of the way in which children learn and discover the world.

**Children have a rich stock of prior knowledge and skills**
The focus of pedagogic work is not on possible deficits but rather on children’s strengths, competencies, and development potential. The strength-based approach “strengthen strengths” is of central importance in this context.

**Children have an inherent desire to learn**
Children do not have to be encouraged or forced to learn. They have an inherent interest in exploring and understanding their world.

**Children actively shape their education and development**
Education and development always involves social interaction, in the course of which children actively construct their own knowledge and their understanding of the world. It is obvious, therefore, that children’s interests and prior knowledge should be made the starting point for pedagogic action.

**Each child has a unique personality**
Because children explore topics via different pathways, they need individual offerings. As there is no such thing as *the* child, there is also no such thing as *the* method or *the* offering. The different interests, abilities, and approaches of individual children represent diversity and are therefore a source of enrichment for us all. An important prerequisite for individual education processes is that early childhood educators and primary school teachers view children in an inclusive yet differentiated way.

**Children have rights**
Human rights are, of course, also children’s rights. They include, for example, the right to education and the free development of the personality. Wherever possible, children should be involved in decision-making processes that affect them (participation).

SIGNPOST

*Every child is different*
*When you vary your methods and offerings in the educational domains of science, mathematics, and technology, you will find that individual children react differently. Some children can best develop their thirst for exploration and inquiry in a very open setting whereas others initially need instructions, a model, or some other kind of “guiding thread” on the basis of which they can develop their own questions and ideas. The pedagogical resources and professional development programme of the “Haus der kleinen Forscher” Foundation are deliberately designed for diversity in order to cater for these different needs and to enhance teachers’ and educators’ repertoire of methodological approaches to teaching science, mathematics and technology.*

# Pedagogic principles of the Foundation

## Children and adults co-construct the learning process

From birth, children explore, investigate, and shape the world around them. Little by little, they construct their own mental model of the world. Although this process is never-ending, it is particularly rapid in the first years of life. Children are open to, and inquisitive about, all stimuli that their social and physical environment offers, and they need a counterpart who treats them as an equal and who encourages and inspires them. "Education processes are therefore interpersonal processes."[18] Learning is a social process that occurs in collaboration and communication with other children and with adults, in the course of which meanings are negotiated and knowledge is co-constructed.

***Prerequisites for co-constructive learning processes***

These co-constructive learning processes call for sensitivity and empathy on the part of teachers and educators: They must be able to identify with, and understand, the thoughts and concepts of the group as a whole and of the individual children (pedagogic attitude). An important task in this regard is to perceive the child with his or her own prior experiences and to support him or her (facilitation of learning). In addition to knowledge of age-typical developmental steps, the exact observation and documentation of the behaviour and reactions of the individual children and of the group as a whole are of great importance. Assessment is facilitated by asking the children questions about their knowledge, actions, and learning processes (learning methodology). It is also very important to create a stimulating learning environment and to give the children enough time for phases of self-education and in-depth inquiry and enough freedom to explore their world. Through this attitude and approach, the children sense that their own questions and explanations are valued as a matter of principle and that they can achieve something themselves (participation).

Successful co-constructive learning processes are characterised by the fact that the teachers and educators perceive children as active constructors of knowledge and culture. Teachers and educators have to be very willing to communicate with the children, to adopt a reflective attitude towards their own learning processes and those of the children, and to have the courage to incorporate their own unanswered questions into the learning process.[19]

Such co-constructive learning processes offer participants the opportunity

- to exchange ideas about the world and become acquainted with mutual interests;
- to jointly generate new content and solve problems, and, when doing so, to get to know different perspectives; and
- to expand their current horizon of understanding and learn something about the world and about their own learning process.

18 Schäfer, G.E. (2014: 113; our translation); cf. also Ostermayr, E. (2006). Vygotsky laid the foundation stone for these deliberations in the 1930s with his "sociocultural theory" (cf. L.S.Vygotsky: Mind in Society [1978], edited by Michael Cole et al.).

19 Cf. Kramer, F. & U. Rabe-Kleberg (2011)

## En route to becoming a facilitator in co-constructive learning processes

The following signposts show ways in which you can foster children's thirst for exploration and inquiry as a facilitator in co-constructive learning processes.

SIGNPOST

### *Preparation*

*Preparation for joint exploration and inquiry with children may be expedient, even when the children's interests are your starting point. With an appropriate learning environment you can induce amazement, prompt questions, and cause children to doubt their current conceptions. Your own engagement with science, mathematics, and technology topics helps you to expand or question your own concepts. Thanks to the experiences that you have gathered in the course of your life, you can be quite relaxed when you embark with the children on a journey to new worlds of exploration and inquiry.*

SIGNPOST

### *Meaningful questions*[20]

*The questions that you ask the children have two main effects: first, you gain an insight into the children's prior knowledge and thought processes; second, the children start to think about their own learning. The questions themselves support them in reflecting on their learning process.*

#### *Questions about the children's knowledge and prior experience*

Here it is a matter of asking about children's personal knowledge, not of assessing whether their knowledge is "correct". To make it clear to the children that it is really they who are being asked, it is important to address them personally, for example with the words: "What do you think/believe is the reason why … is …?"

#### *Questions about action and the process*

"How can we proceed?" "What do we need?" "What do you see/observe?" "What will happen if …?" "How must you blow/run/pull so that …?" "What method could you use in order to …?" "What would happen if … (variations)?" "Why does that work/not work?"

#### *Questions about the children's learning process*

"What surprised you?" "What did you think beforehand and what do you think about it now?" "How did you find that out?" "How do you know that?"

#### *Questions that adult facilitators of learning can ask themselves*

What are the children's interests and how do I recognise them? How can the children see that I recognise their interests? How do I talk to children? How much time do I give them to formulate their own thoughts? What, in my observation, do the children learn from each other?

SIGNPOST

### *When is it time to engage in reflection?*

*Keep an eye out for the right moments for reflective phases. During inquiry activities, children are often engrossed in their actions and observations. So much so, that it can be difficult to get them to verbalise their observations and thoughts while they are engaging in inquiry activities. Interruptions may even disturb the children's activities. Therefore, it is better to use the time after the inquiry-activity phase to talk to the children about what they have experienced.*

SIGNPOST

### *Collaborative documentation*

*Ask the children about the things that they find so important that they would like to document them, and ask them how they think this should be done. You can also make suggestions yourself. Documenting things in this way can promote the children's learning process because when they look at their documentation later they become more aware of their own problem-solving and learning strategies.*

SIGNPOST

### *Observation*

*Observing children's activities means refraining at first from giving prompts. This enables you to perceive the children as individuals. Try to assume the perspective of the individual children. What is the child doing? What does he or she intend to do? It is also worthwhile to critically ask yourself: What might I be overlooking here? What is genuine observation, as opposed to interpretation?*

20 For further questions and background information, see Elstgeest, J. (1995: 151–158)

# Pedagogical objectives of the Foundation

## Objectives at the level of the children

At the level of the children and their development, the “Haus der kleinen Forscher” Foundation pursues the following objectives (see Figure 3, page 24):

**To foster enthusiasm, inquisitiveness, and interest in exploration and inquiry**
The “Haus der kleinen Forscher” Foundation considers enthusiasm, inquisitiveness, and interest to be essential keys to a positive approach to science, mathematics, and technology. As a rule, children have their own initially unbiased perspective that is characterised by inquisitiveness. Via an interest in phenomena, this perspective can yield an understanding of basic scientific, mathematical, and technical relationships. Moreover, brain research findings suggest that positive emotions enhance concentration.[21] Therefore, enthusiasm and inquisitiveness support learning.

**To enable children to practise using an inquiry-based approach and develop their problem-solving skills**
An inquiry-based approach includes, for example, the ability to consciously experience and perceive phenomena, to observe and describe them, and to compare experiences. Children can then derive predictions and assumptions from this, which they can test by trying things out and experimenting. Their own experiences contribute to understanding basic scientific, mathematical, and technical relationships and encourage them to engage in further deliberation (see Part C “Investigating together – The Inquiry Cycle”). Through the cyclical approach to inquiry, the children expand their methodological and problem-solving skills and learn to find their own answers to their questions.

**To enable children to grasp basic scientific, mathematical, and technical concepts**
During the inquiry process, the children have basic experiences with natural phenomena. Little by little, they discover relationships between things, acquire individual knowledge about scientific, mathematical, and technical phenomena, and grasp basic concepts in these areas. They recognise, for example, that liquid water and ice are two states of one and the same substance. At zero degrees Celsius, liquid water freezes to solid ice. When the temperature rises, the solid ice melts and becomes liquid water.

**NOTE**

*You will find examples of the development of mathematical and technical competencies in the brochures “Mathematik in Raum und Form entdecken” [Exploring mathematics in shape and space]*[22] *and “Technik – Kräfte nutzen und Wirkungen erzielen” [Technology – Using forces and achieving effects]*[23].

[21] Cf. Kiefer, M., Schuck, S., Schenk, W., & K. Fiedler (2007)
[22] Cf. Stiftung “Haus der kleinen Forscher” (Ed.; 2014)
[23] Cf. Stiftung “Haus der kleinen Forscher” (Ed.; scheduled for publication in 2015)





**To strengthen children’s sense of self-efficacy – “Yes, I can!”**
With time, children feel more and more confident when investigating, communicating, answering their own questions, and solving problems that can crop up along the way. In their engagement with science, mathematics, and technology they experience a feeling of self-efficacy.[24] This strengthening of children’s self-efficacy and self-confidence is a key objective of the “Haus der kleinen Forscher” Foundation. Increased self-confidence and inner strength is essential when it comes to reacting flexibly to the demands of changing situations and mastering difficult or eventful phases in life – for example, the transition from kindergarten to primary school. Current research findings confirm that children who are self-confident and strong are much more resilient and find it much easier to cope with the changes and burdens of everyday life than children who lack this confidence in their own competencies.[25]

By taking up children’s questions and jointly seeking answers with them, a number of other competencies are strengthened that children need for their journey through life:

Learning and metacognitive skills
The amount of information available today, and the speed with which it is changing contemporary society, renders it simply impossible to assimilate this information in its entirety as a “pool of knowledge”, so to speak. Hence, learning does not mean only an increase in knowledge but also, and in particular, the expansion of the repertoire of the strategies with which children solve problems and acquire knowledge. Of particular importance in this regard are the phases of reflection during the inquiry process in which questions (e.g., “How did you find that out?”) stimulate reflection on the learning process (metacognition).

Social skills
Social skills are needed to successfully build up relationships with other people and to treat them with respect. This means, for example, that every person can take responsibility for him- or herself and for his or her actions. During exploration and inquiry processes, social skills can be strengthened, for example when children negotiate collaborative procedures, exchange ideas, and jointly establish rules.

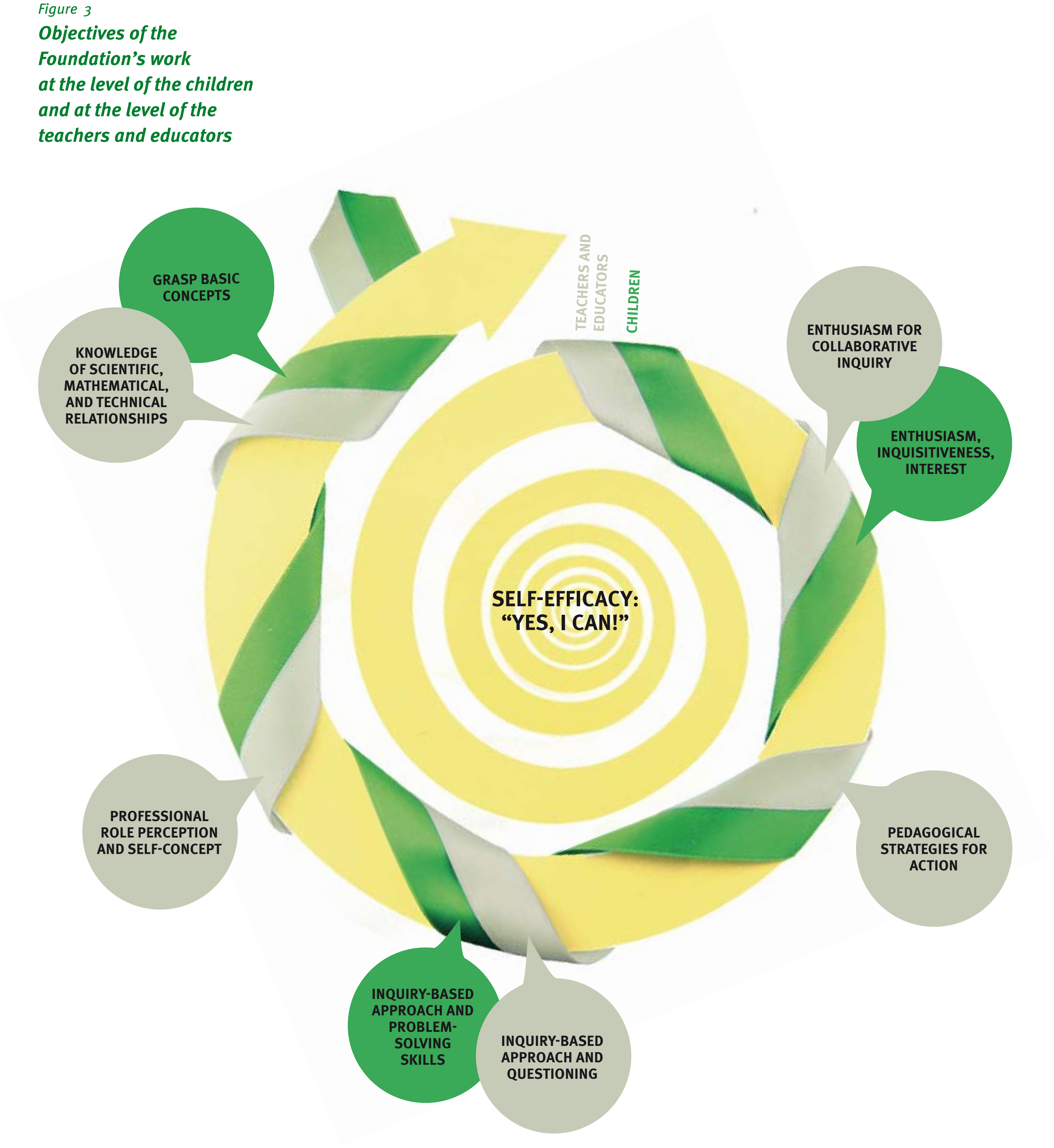
Language skills
Language is an essential prerequisite for a successful educational biography and for participation in society. Dialogue is a key component of the process of scientific exploration and inquiry – and of the reflective phases, in particular. Language education during the exploration and inquiry process can take place, in particular, by explicitly encouraging the children to express their assumptions, to describe their observations, to name the materials they use, and to formulate their own explanations.

**HINWEIS**

*The Foundation’s brochure “Sprudelgas und andere Stoffe” (Carbon dioxide gas and other substances) focuses on language development and features examples of how language education can be incorporated into scientific exploration and inquiry.*[26]

[24] Self-efficacy is defined as the belief in one’s ability to master challenges.
[25] Cf. Rutter, M. (2000); Werner, E. E. (2000)
[26] Cf. Stiftung “Haus der kleinen Forscher” (Ed.; 2013)

*Figure 3*
***Objectives of the Foundation's work at the level of the children and at the level of the teachers and educators***




**When they engage in collaborative inquiry, children and teachers and educators develop their skills in various areas.**

## Objectives at the level of teachers and educators

At the level of early childhood educators and primary school teachers, the "Haus der kleinen Forscher" Foundation pursues the following objectives:

**To foster enthusiasm for collaborative inquiry**

Adults have often lost some or all of their enthusiasm for, and curiosity about, scientific topics in the course of their educational career. Together with the "Haus der kleinen Forscher" Foundation, teachers and educators set out to integrate the fields of science, mathematics, and technology into the everyday life of their respective primary schools, after-school centres, and early childhood education and care centres. This calls for an open-minded approach. Therefore, one key objective of the Foundation's professional development programme is to enable participants, first and foremost, to develop a positive attitude to scientific inquiry (once again).

**To promote an inquiry-based, questioning approach**
Through their own actions and questioning when investigating scientific, mathematical, and technological phenomena, teachers and educators proceed in an inquiry-based manner and adopt a processual, cyclical approach. They compare and assess experiences, develop predictions and assumptions, try out ideas, and reflect on their observations. The Inquiry Cycle method (see Part C) aims to encourage both children and adults to discover scientific, mathematical, and technical relationships through their own activities and inquiry-based approach and to increase their understanding of science.

**To deepen knowledge of scientific, mathematical, and technical relationships**
A basic knowledge of the topics under investigation helps teachers and educators to facilitate children's understanding of scientific, mathematical, and technical relationships. In this way, they feel more confident about these topics and can give the children tips and hints during the process of collaborative exploration and inquiry. The Foundation's offerings support teachers and educators in deepening their knowledge of scientific, mathematical, and technical relationships. For example, the Foundation's thematic brochures always feature a chapter on the scientific background of the topic in question.

**To broaden the range of pedagogical strategies for action**
Teachers and educators play an active role in co-constructing learning processes. During the Foundation's professional development workshops they become acquainted with concrete pedagogical strategies for action that they can use to facilitate children's learning processes. These strategies include taking account of the way children typically conceptualise certain phenomena and designing suitable learning environments.

**To build self-confidence as a facilitator of learning**
Through the Foundation's professional development workshops and collaborative inquiry with the children, teachers and educators build self-confidence in relation to facilitating the children's scientific, mathematical, and technical learning processes. As their knowledge about basic substantive relationships and scientific inquiry procedures increases, and their range of pedagogical strategies for action becomes broader, teachers and educators experience greater self-efficacy with regard to their ability to (co-)construct scientific learning processes. Because they experience themselves as competent, their confidence in their own abilities can be generally strengthened.

**To promote the further development of teachers' and educators' professional role perception and self-concept**
In order to be able to meet the increased demands on teachers and educators in the preschool, school, and extracurricular education sectors and to master the diversity of tasks, it is important that they address their role in learning processes, the individual teaching-learning process, and pedagogic concepts, and that they critically and constructively assess their own pedagogical action. Moreover, their attitude to engaging in inquiry with children and collaboration among the teachers or educators themselves also play an important role.

The development of one's own professionality is a lifelong process and depends on one's willingness to undergo continuing professional development and to bring one's professional knowledge and skills up to date. The continuing professional development programme of the "Haus der kleinen Forscher" Foundation supports teachers and educators in following this path.

**FURTHER READING**

*If you would like to obtain a deeper insight into the pedagogic objectives of the Foundation, Volume 5 of the Foundation's series "Wissenschaftliche Untersuchungen zur Arbeit der Stiftung 'Haus der kleinen Forscher'" [Scientific studies on the work of the "Haus der kleinen Forscher" Foundation] features two chapters by the experts Yvonne Anders, Ilonca Hardy, Sabina Pauen, Beate Sodian, and Mirjam Steffensky on the "Dimensions of the objectives of early childhood science education" (2013; also available as a downloadable PDF at www.haus-der-kleinen-forscher.de)*

In sum, the following pedagogic principles can be identified in relation to science education and the facilitation of science learning. They are based on the "Flensburger Erklärung zur Frühen Naturwissenschaftlichen Förderung" [Flensburg Declaration on Promoting Early Childhood Science Education]: [27]

- Encounters with science-, mathematics-, and technology-related questions promote inquisitiveness and enthusiasm for these thematic fields.
- Children have the opportunity to independently investigate scientific, mathematical, and technical topics.
- Exploration and inquiry call for sensitive facilitation; children need individual support.
- Children learn together and exchange ideas and experiences.
- Teachers, educators, and children focus not only on content and activities but also on the learning process itself.
- The educational fields of science, mathematics, and technology are not isolated offerings in the respective institutions but are embedded in complex contextual relationships and, where possible, intertwined with other activities.
- Documenting and reflecting on activities supports the children's learning process.
- Teachers and educators regularly exchange ideas and experiences with pedagogical colleagues. This promotes self-reflection and yields new ideas for their work.

[27] At the conclusion of a conference in March 2009 in Flensburg entitled *Am Phänomen lernen. Naturwissenschaftliche Förderung im Elementarbereich* [Learning from phenomena. Promoting science education in the pre-primary sector], a position paper was drafted by the participating researchers and project groups. The aim of the declaration is to heighten awareness of the extraordinary importance of early childhood science education; it formulates pedagogic principles and demands in this regard. (Cf. Flensburger Erklärung, 2010)



# PART C

# Guide to implementation



## Exploring together – Investigating together

The way in which we access scientific, mathematical, and technical topics is shaped by our own actions and observations. It starts with almost incidental discoveries in everyday life that can enthral both children and adults: sand slipping through our fingers; raindrops that sometimes stick to the window and sometimes roll down the pane in zigzag lines; sugar that dissolves in tea and seems to disappear. The astonishment and enthusiasm triggered by such observations encourages us to investigate further.

SIGNPOST

***Explorations***

*Inquiry as a knowledge acquisition process is preceded by a phase during which children acquire basic experiences and spend a lot of time trying out and repeating things. Teachers and educators, as facilitators of learning, sometimes find this phase difficult to bear, especially when the intended learning experience is an in-depth and systematic engagement with the phenomena in question. However, before children can develop specific questions and assumptions and decide what they wish to focus on, it is essential that they have extensive basic experiences with phenomena and materials.*

SIGNPOST

***Investigations***

*Targeted inquiry begins when children come upon a question that they would like to investigate in greater depth. Can water be cooled as quickly as it can be heated? How can water be transported? Questions such as these encourage children to think of ways of testing their assumptions, analysing their findings, and discussing them with the other children and with adults.*

SIGNPOST

***Facilitating learning***

*When engaging in exploration and inquiry, teachers and educators co-construct the learning process with the children. In a co-constructive learning situation, they set out together in search of answers and discuss their understandings with each other. Teachers and educators encourage the children to collect information, data, and descriptions of their observations, to describe their perceptions, to ask other children about their ideas, and to take in and repeat the knowledge thus acquired. Ideas for learning are linked to children's ideas and their experiential world so that they themselves can develop and reflect on scientific, mathematical, and technical knowledge.*

# Exploring together – It can be done anywhere

The “Haus der kleinen Forscher” Foundation receives many reports from early childhood educators and primary school teachers about their experiences during their voyages of discovery with the children. One thing can be deduced from all these reports – namely, that exploring the world with children means knowing them, having a good relationship with them, placing trust in them, being sensitive to the situation, and also having a large portion of equanimity. By way of example, a number of these experience reports are summarised in what follows.

*Was tun, wenn es dampft?*

“I’m sitting with my group at breakfast. Eleven children are here, all between the ages of three and six. They still seem to be a bit tired, because it’s quiet; most of them are simply eating away. My colleague from the other group comes in with the jug of tea.

Erik exclaims, ‘There’s steam coming out of the jug of tea!’ and Lilly wants to know: ‘Can we drink it already?’ I don’t know either whether the tea is already cool enough. Normally the tea is made early and it is cool enough to drink by now. But today it seems to be different, for, as Erik put it most succinctly, there is steam coming out of the jug. And Lilly, at least, seems to know that tea that is steaming may be too hot to drink.

All this is going through my head as lively action spreads around the table. Fritz and Ella hold their hands to the jug; Freija pushes Björn’s hand aside because she also ‘wants to feel how hot it is’. Odin even holds his face over the jug. Dilek wants to take the jug away. ‘No!’ the others exclaim, and before a fight starts and the hot tea spills, I intervene: ‘Dilek, what do you intend to do?’ ‘We have to make the tea cooler,’ she says. ‘Ah!’, I say, ‘Yes, of course,’ and Dilek places the jug on the window sill. Björn goes over and starts to blow. The younger ones in the group also appear to be familiar with that because they come over, push their way to the edge of the jug, and join in the blowing.

I feel a little apprehensive. What if the tea jug falls over? Or they blow so hard that hot drops splash into the face of one of the children? I think about what I should do. Let them continue? Pour the tea into several glasses? Then I would have to keep an eye on lots of children who could scald themselves. But they could try things out at their own pace. We could collect their ideas beforehand. And then compare which cooling method is the best. But should I interrupt everything now? Probably none of them would listen to me anyway. I’ll leave it for a minute; let’s see what happens. I wait, watch, and merely make sure that nobody scalds themselves on the hot tea.

‘Hey, you’re spitting into it!’ says Fritz in disgust because Achmet blew too hard. ‘Can I have a glass? I want to put it into the refrigerator.’ A glass, okay, – so now we have lots of glasses instead of just one jug, after all. Then I’ll have to be even more careful. But in the refrigerator the glass is safe and I can help with pouring.

‘Yes,’ I say, ‘get one from the kitchen,’ while Freija and Björn disappear into the bathroom. ‘We’ll run some water into the sink; that also cools.’ I send them to fetch another glass. In the meantime, Lily helps Fritz to pour, and Achmet and Skyla want to put ‘their glass’ ‘outside on the window [sill]’. ‘With or without a lid?’ I ask, and Lily says: ‘Without [a lid] the tea will get dirty.’ Once all the children have filled their glasses under my supervision, I get a plate for Achmet’s and Skyla’s glasses. Together, we put them on the window sill – outside. By now, the jug is almost empty and the children’s thirst for exploration is beginning to wane.

My goodness! Somehow I’m relieved that nobody came to any harm. But I’m pleased with the children’s ideas. They all joined in; they all had ideas. Even the youngest ones. My plan to leave all the tea in the jug didn’t succeed, of course. But things worked out okay the other way. Now we can clear off the table, the children can clean their teeth, and I’ll write down what happened. After all, the parents want to know what the children do all day.

We’ve just finished in the bathroom and I have just sat down to write things down when it starts again because Freija and Björn brought ‘their tea’ from the bathroom and the others are now allowed to fetch ‘their glasses’. ‘Mine has got cold.’ ‘But mine got colder faster!’ ‘Daddy always pours the tea back and forth.’

I ask the children whether they would like to investigate exactly which method is most suitable for cooling. ‘Yesss!’ the five older ones exclaim, and they run off because they want to make fresh tea straight away. The smaller ones prefer to go to the building corner.

What should I do? The older ones would do the same thing as they did earlier: cool the tea somehow; everyone in his or her own way; unsystematically. I would find that super. I know that they need repetition. But to start from the beginning, all over again? And Vincent, Klara, and Caroline want to put on a play in their cave. We agreed on that before breakfast and they are already jostling. The tea-cooling activity has to be accompanied, for safety reasons, at least.

‘Stop!’ I call them back. ‘It’s not a good time now. You can go to the inquiry corner with the cold tea. Just three children. Maybe it will get even cooler. Or maybe it will get warmer?’ Erik is pleased: ‘We’ll put the rest in the refrigerator. And then we’ll wait until tomorrow. Then it will be really cold.’ And Freija says: ‘Maybe it’s even frozen by then!’ Dilek explains: ‘In summer we always leave tea in the refrigerator. It has never frozen there. But now it’s winter.’

Oh, oh, oh, so many concepts! And so much confusion. I just listened. Should I intervene? Should I explain the world to them? No, I'll leave it be. I'll wait. I'll let them cool their tea and see tomorrow whether it is frozen. By tomorrow they will probably have forgotten that they thought that today. I will keep it in mind if I manage to make a note of it in their development books. In any case, I will remind them of it tomorrow. And see what other things they come up with ….”

Ideally, the teacher or educator lets the children go on exploring what is still to be explored. The tea does not freeze, and next morning the children could be asked whether it can get warm again. That may interest the children again only after a few days. They often have other plans. Perhaps they want to pipette the tea into another vessel because tea might behave differently than water; or they want to try to find out why tea can be different colours (sometimes it is bright red, sometimes dark red, sometimes brown). And if very warm tea is brought once again, the children will cool it again. This phase can last for weeks, or even longer. The children make so many discoveries and they formulate findings that are sometimes hair-raising from a grown-up's perspective. But they also test many of their concepts by trying them out. At some point, an opportunity may arise for the teacher or educator to investigate more thoroughly with the children. For example, from the many topics that the children have touched on during the exploration phase, she may choose the one with which everything began and ask the children: “Which method is actually best for cooling tea?”





# Investigating together – The Inquiry Cycle

The process of inquiry can be divided into phases of thought and action that typically occur in a recurring cycle. In what follows, the individual phases of this method are presented in detail and illustrated by a concrete example from the topic area “water”.

*Figure 4*
***The Inquiry Cycle describes a method of scientific inquiry***


**The Inquiry Cycle should be understood as a model or a tool that shows you how you can conduct inquiry activities with boys and girls and engage in dialogue with them about natural phenomena. It provides orientation for open-ended inquiry with children. However, in everyday pedagogic practice it must not always be meticulously adhered to. Shortcuts and backward steps are permitted – even grown-up researchers sometimes take them!**

## Ask a question about the natural environment

Natural phenomena are part of children's experiential world. Children have a strong motivation to understand their world – to "grasp" it, literally and metaphorically – and, in doing so, to find out more about phenomena and relationships in the natural environment. Children's everyday lives offer many opportunities that can be used for pedagogical purposes. Their own questions should always play a central role in the process of exploration and inquiry.

**What you can do:** To find a starting point for the inquiry process, you can either take up a question asked by the children and make it the topic of inquiry or you can introduce a phenomenon or a question yourself – ideally one that originates in the children's observations. Remind them that, and where, they have already been able to observe this phenomenon themselves. Always relate the topic to the children's life-world.

INVESTIGATING WATER

*The freshly made tea that is still too hot to drink offers a good starting point for an inquiry process. Almost every child has experienced this and has asked: "How can I cool the tea down so I can drink it sooner?" Make some tea for yourself and explain your dilemma to the children: freshly made tea but much too hot to drink. Place your glass of tea in the middle of the table and let the children observe it. At first, they will see the steam rising; after a while the steam will subside. Hold the tea glass firmly and allow the children to touch it carefully with one finger. They will quickly withdraw their finger. What could be done to cool the tea?*

## Collect ideas and assumptions

Sometimes, children already have lots of ideas and assumptions. And they often also have some idea of what exactly they want to find out. Talk to the children about their ideas. Some children cannot, or do not want to, formulate their ideas precisely. However, their actions often provide an insight into their assumptions. As a facilitator of learning, you can address the children directly and ask them to explain what they are doing.

**What you can do:** You can enable the children to activate their prior knowledge by asking them the following questions: Do they know the phenomenon? How did they get to know it? Have they experienced something similar? What did they do on that occasion? After this round of questions, collect the children's suggestions and assumptions: "What do we want to know?" "How can we find that out?" "What material could we use?" Take note of the children's assumptions and of their ideas about how these assumptions could be tested, and show them that you genuinely value their thoughts.

INVESTIGATING WATER

*Discuss with the children how they typically deal with hot drinks. What do they usually do to reduce the temperature? What happens when you do nothing?*

*After this brief activation of the children's prior knowledge, consider together what you want to try out to cool the tea. Collect all the children's ideas (e.g., stir the glass of tea, pour it back and forth from one glass to another, place the glass in a bowl of cold water or in the refrigerator, etc.). Ask them to give reasons for their ideas. Why do they believe that their respective methods will work? And which of the proposed methods is actually the most effective? The more prior experiences the children have, the more specific their subsequent questions will be. For example, you could discuss with one group how many ice cubes are needed, or whether it makes a difference what the spoon that is used to stir the tea is made of. How can you find out how hot the tea is? Some children may be familiar with thermometers and may have even used one themselves. Look at various types of thermometers with the children and try them out.*

*To make sure that no idea is forgotten, make a note of the children's suggestions and encourage them to draw pictures of their own assumptions or to write them down. The collection of all the ideas reveals the diverse methods, which can now be tried out.*

## Try things out and engage in inquiry activities

In the next step, the ideas and assumptions that have been collected are investigated. As a rule, this phase takes up a lot of time, and children often feel the need to repeat certain inquiry activities several times.

**What you can do:** If you and the children have collaboratively planned the inquiry activities, you can keep a low profile during this phase. Give the children the time and the peace they need to engage in their inquiry activities and to gain their own experiences. Observe them while they work and give them support in searching for materials. Do some children feel the need to discuss things with you? If the children have already tried out lots of things, it may be helpful to broaden the topic. The main way of doing this is to join in the activities yourself or – if you have not yet got an impression of the group in question – to ask the children about their observations. Hence, you can also combine the phases "trying things out and engaging in inquiry activities" and "observing and describing" rather than having them take place consecutively.

INVESTIGATING WATER

*Each child can now decide which ideas he or she would like to try out: leave the tea standing; blow it; stir it; place the glass in a bowl of cold water; add ice cubes, etc. To enable them to gather the desired experiences, give the children the opportunity to test their assumptions and to carry out all the inquiry activities that interest them.*

*After many ideas have been tested, you can deliberate with the children: "How can we compare which variant cools the tea down best?" For example, they can make a note of the temperature of the tea at certain intervals (after one minute, after two minutes, etc.).*

*To enable the children to work independently, please use only temperatures at which they cannot scald themselves (a maximum of 40 degrees Celsius). Begin the inquiry activity by pouring the hot tea into glasses and start measuring the time. The timer should be visible for all to see. One child can be responsible for making sure that everyone measures the temperature of the tea at the agreed intervals.*

NOTE

*Dirt, mess, and slop are often unavoidable when children engage in inquiry activities. Once in a while, something inevitably tips over. That is all part of the inquiry process, and "accidents" such as these can also be regarded as a sign that the children are particularly motivated. You can use these little mishaps as an occasion for further exploration. What type of cloth or paper is most suitable for mopping up spilt tea? Of course, not all incidents can be used as an opportunity for inquiry, but by remaining relaxed when things get a bit messy you will encourage the children to engage wholeheartedly in free inquiry.*



## Observe and describe

As a rule, the children will make numerous observations and discuss them among themselves and with the adult facilitators. This can happen during the inquiry process when you are interacting more intensively with one group of children or you have only a few children in the group. In instructional situations, or in the case of large groups, it can also take place after the inquiry activities have been completed. What is important is that the children have the opportunity to actively realise the experiences they have had.

**What you can do:** Ask the children to observe the processes very closely and to describe them carefully: What exactly happened? What did they see? How did the things behave? Encourage the children to perceive changes not only visually. Draw their attention to the fact that during the inquiry activity they can also pay attention to smells, noises, and, especially, to their sense of touch. Through targeted questioning and hints, you can draw their attention to further peculiarities.

NOTE

*Some teachers and educators use hand puppets for their pedagogical work. The puppet introduces the inquiry topic. While the children try out their ideas, the puppet tends to fall asleep. As soon as the children are finished, it wakes up from its nap and asks them what has happened and what they have observed. Experience shows that young children, in particular, much prefer to talk to, and share their impressions with, a puppet than a teacher or educator. After all, the teacher or educator was awake the whole time and must be aware of what went on. Because the puppet is sometimes a bit slow, the children have to explain and describe very precisely. This in turn helps them to verbalise their actions and thoughts in the most differentiated way possible.*

INVESTIGATING WATER

*The children can feel the change in temperature first with their hands and then by holding the glass to their cheek. Do they notice the difference? What do they observe when they use the thermometer? Do they see that something has changed in the bowl of cold water in which the glass of hot tea is standing? Do all the children feel the same thing? What happens to the ice cubes in the hot tea?*

*The more experienced and interested the children are, the more they are able to ask specific questions. For example: Do the ice cubes start to melt straight away, or when are the first changes to be seen?*

## Document results

Documentation is not only important in order to make the diverse activities of the institution visible to the outside world (for example to parents). It also helps the children, in particular, to recall certain experiences and to reflect on their own learning processes.

**What you can do:** Ask the children to draw pictures of their results or to write them down, to take photos, or to record measurements. In this way, you will see which aspects, things, and experiences were especially important to them. Prepare wall newspapers or portfolios with the children so that others can share the knowledge that has been gained. You can also photograph the sequence of the inquiry activities and get the children to arrange the prints in the correct order. In this way, inquiry activities conducted with the children can be reflected on in conversation, approaches and solution processes can be understood, and key situations can be identified once again. Make a note of the children's utterances. Primary schools students can write down their results themselves. Other documentation possibilities for primary school students are inquiry diaries and self-prepared learning and photo collages.

INVESTIGATING WATER

*For every cooling method, the temperature of the tea is measured and felt after one minute, after two minutes, etc. Older children can enter the temperature into a table or into an online diagram generator, for example at www.meine-forscherwelt.de. Children who cannot yet read or write can draw different coloured lines on a drawing of a thermometer (e.g. blue for cold; orange for lukewarm; red for hot). At the end of the investigation, the thermometer poster features numerous lines that reflect a trend from hot to cold. The children can also prepare a large joint poster showing all the individual inquiry activities and the respective temperatures at a certain time of measurement (e.g., after three minutes). Pictures and photos of the children's "own" glasses of tea help them to remember and reflect on their inquiry activities. In order to compare the different methods of cooling, the children can arrange the photos in the order of the temperatures reached in the glass of tea.*

## Discuss results

The main point of the discussion of the results of the children's inquiry activities is to discuss whether the original question has been answered, which original assumptions were correct and which were not, which questions remain open, and what new questions have arisen. It is important to discuss not only the things that the children have found out, but also to reflect on the way in which these findings were achieved.

**What you can do:** Discuss the results with the children. What did they observe? What did the other children find out? What worked well? What didn't? How did the children proceed? How did they overcome the obstacles they encountered? Did they intend from the beginning to do what they finally ended up doing, or did the question change during the inquiry process? If that was the case, how did it come about? Did more in-depth or new questions arise? If the question could not be answered, were you able to collect new ideas and assumptions with the children about how the question could be answered after all? Experience shows that children come up with new ideas because their horizon of experience has been extended through the inquiry process. Hence, the inquiry cycle can be repeated again and again until the children have found subjectively satisfactory answers to their questions.

INVESTIGATING WATER

*With the children, look at the order in which the pictures on the poster are arranged. Compare the different cooling methods and consider how this sequence came about. Was there one method that was obviously superior to the others? How do the children explain to themselves that the hot tea cools down faster with the one method than with the other. Jointly, consider whether an answer has been found to their original question: "What can we do to cool freshly made tea faster?" With experienced children, you can discuss whether two cooling methods could be combined. Would this approach cause the tea to cool faster?*

*New questions may possibly crop up: What if you used a completely different container for the tea? Does it cool down faster in a ceramic cup than in a glass? And what about a porcelain cup? Does twice the amount of hot tea take twice as long to cool?*

SIGNPOST

*The duration of individual phases of the inquiry cycle is by no means fixed. Each phase can take minutes, hours, days, weeks, or even months. Exploration and inquiry is, of course, always a very individual process. Therefore, the task of the facilitator of learning consists not only in supporting the group of children in these generally identifiable phases of inquiry but also in recognizing and taking into account each child's individual characteristics.*

# Handling questions and explanations

When children ask...

With a view to pedagogically supporting the children in a targeted way, it may be helpful to consider one or two possible learning experiences that the children could have in relation to the topic in question before they embark on their inquiry activities. What could they observe? What basic relationships could they recognise? With this objective in mind, teachers and educators can, where necessary, moderate the inquiry process by means of suitable questions and hints, thereby helping the children to answer their questions themselves.

The way a question is formulated prompts a certain type of reply. Teachers and educators should ask questions in such a way that they can be answered by the children. "How" questions are suitable for use as inquiry questions (e.g., "How does snow behave indoors?"). Action-oriented questions ("What happens, when ...?") encourage the children to search for an answer by doing something themselves – for example, by engaging in an inquiry activity. Questions that prompt children to observe and describe ("What do you see?" "What is happening?") generally support language development. After the children have completed their inquiry activities, the facilitator of learning asks them questions that encourage them to reflect on the learning process and therefore support the development of metacognitive skills ("What do you think about it now?" What did you think beforehand?" How did you find that out?").

Children's "why" questions are not always motivated by the desire to obtain a scientific explanation for a particular phenomenon. What they mean by a question and what adults think they mean are not necessarily one and the same thing. Therefore, it is important to find out first what exactly the child wants to know.

During the process of exploration and inquiry, a child asks: Why is it that the tea gets cold? To find out what exactly is of interest to the child, you could react with a counterquestion: "What do you think is the reason why the tea gets cold?" Experience shows that there are different levels of answers:

***Level 1:*** *"I don't know. You tell me." (For example, the child might answer your counterquestion as follows: "Maybe it's because ... But I'm not sure and that's why I'm asking you.") In this case, the child is probably interested in a scientific explanation.*

When children appear to be interested in a scientific explanation, you should talk to them about your knowledge. Answer their questions in such a way that they realise that your are not omniscient and that it is still worthwhile to contribute their own ideas and interpretations. For example, you could say: "I learned that ...", "I believe that ...", "Can you also imagine that?" or "What do you think?"

If you do not know something, tell them so, and then offer what you consider to be a possible answer. By saying something like: "I don't know, but maybe it could be ....", you show the children that you are pondering the question and encouraging them to express their own assumptions as well.

After exchanging suggestions, you could jointly deliberate with the children whether a certain idea could be proved by means of an inquiry activity.

For example, if the conversation with the children yielded the unanimous conclusion that the tea gets cold because the ice cubes cool it down, discuss with the children how this could be proved. Formulate your assumption: "If the ice cubes cool the water, would the tea in the area where ice cubes are floating not have to be colder than the tea further down in the glass?" How do the children think that this could be demonstrated? For example, could one measure the temperature of the tea near the ice cubes? What would be the best way to do that? At this point, the next inquiry cycle can begin. Even if there is no time for a new inquiry question, it is still good to reflect on a possible further inquiry activity. You may not know whether the explanation that the children have found with your support corresponds to the currently valid scientific explanation. However, that is not important. You cannot possibly have the scientifically exact definitions at your fingertips to enable you to answer every question. But, what you can do is to ponder questions and expand or change your concepts in collaboration with the children. If it bothers you that you are not making progress, you can, and should, consult books or scholarly journals or undergo continuing professional development with the help of experts. However, you should always question whether you are still capturing the children's interest and, if this is not the case, whether you should set off on your own in search of even better solutions.

***Level 2:*** *"The tea has to get cold. Otherwise I couldn't drink it." Children who reply to your counterquestion in this, or in a similar, way often do not expect a scientific explanation as to why the tea actually gets cold; nor are they interested in further inquiry activities.*

Children who reply in this way are concerned about the effect on themselves. Replies of this kind frequently occur among children in science, mathematical, and technical contexts. For example, in a survey of children and adults we asked how a filling station petrol pump works. All the children replied that you have to insert it into the car and press it. By contrast, the adults gave us their ideas about how the valve mechanism works. This finding can be viewed as an indication that a) you should always find out exactly what intention the child who is asking the question has, and b) the questions that you ask may be understood quite differently by the children than you intended.

**Background knowledge for interested adults**
on the above inquiry example:
When two substances of different temperatures are in thermal contact, heat flows from the higher-temperature substance into the lower-temperature substance, raising the temperature of the heated substance and lowering the temperature of the substance releasing heat until thermal equilibrium is reached and the temperatures of both substances are the same. Hence, heat flows from the hot tea into the immediate environment – that is, the glass and the air. If the glass is standing in a bowl of cold water, heat also flows into the cold water, thereby raising its temperature.

# Handling the Foundation's pedagogical resources

The Foundation's pedagogical resources – such as the thematic brochures, the sets of exploration and inquiry cards for early childhood educators and primary school teachers, the sets of cards for children and the accompanying pedagogic manual, and the website for primary school students – represent a body of knowledge, ideas, suggestions, and tips on how to explore and investigate science, mathematics, and technology topics with the children in everyday life.

## Exploration cards

*The **exploration cards** provide ideas with which children can experience natural phenomena in their everyday lives. These ideas can be applied repeatedly, modified, and supplemented by the children's own suggestions. The explorations are essential to enable children to ask further questions about the natural world – the prerequisite for engaging in scientific inquiry.*

## Inquiry cards

*The **inquiry cards** demonstrate exemplarily how a question can be investigated using the Inquiry Cycle method. They show how teachers and educators can embark on a process of inquiry with the children and how they can allow themselves to be guided by the children's concepts, assumptions, and ideas for inquiry activities.*


## Thematic brochures

*The Foundation's **thematic brochures** offer ideas on how to implement exploration and inquiry with children in various fields. In addition to many practical tips – for example for project work – the brochures highlight the way in which a topic can be integrated into education plans and curricula, and they present developmental psychology prerequisites and scientific background information on the respective focal topics.*

**NOTE**

*With increasing experience, the resources will probably be needed less and less because users have the necessary basic knowledge and ideas – and the self-confidence to pursue them independently. It is a bit like cooking. When you are learning to cook, you prefer to follow an exact recipe in order to make sure that the dish is a success. But the more often your cooking succeeds, and the more experience you gather, the more self-confident you become in the kitchen. You start to modify recipes, and the cookery book eventually stays on the shelf.*


## Sets of cards for primary school students

*The **sets of cards for primary school students** address the children directly. They encourage them to actively engage with an idea or a question. The children can take up these suggestions exactly or they can modify them and develop their own inquiry activities or projects.*


*The pedagogic **manual** that accompanies these cards addresses the facilitators of learning. It outlines strategies that can be used to encourage and support the students and offers further recommendations for action in this field of inquiry.*

## Website for primary school students

*The **website for primary school students** is a playground, think tank, and a forum for the exchange of questions and ideas for all children between the ages of six and ten. Learning games enable the children to try out their own solution strategies. In the "workshop" (Werkstatt), they can find tips on what and how they can investigate further beyond the computer. And at the "meeting place" (Treffpunkt), they can ask their own questions and other children can answer them.*
***www.meine-forscherwelt.de***

# Five steps to certification as a “Haus der kleinen Forscher” (Little Scientists’ House)

## Prerequisites

SCIENTIFIC INQUIRY IS AN INTEGRAL PART OF YOUR INSTITUTION’S EVERYDAY ACTIVITIES

TWO PROFESSIONAL DEVELOPMENT WORKSHOPS IN THE AREA OF SCIENCE, MATHEMATICS, AND TECHNOLOGY ARE ATTENDED EACH YEAR

EDUCATIONAL ACTIVITIES, E.G., PROJECTS, INQUIRY ACTIVITIES, AND OBSERVATIONS, ARE DOCUMENTED

1

2

THE APPLICATION IS SUBMITTED ONLINE VIA THE WEBSITE WWW.HAUS-DER-KLEINEN-FORSCHER.DE.

3

THE FOUNDATION EXAMINES THE APPLICATION ON THE BASIS OF PRE-ESTABLISHED QUALITY CRITERIA

4

YOU RECEIVE FEEDBACK ON YOUR APPLICATION

5

CONGRATULATIONS!
YOUR INSTITUTION IS CERTIFIED!


Make your commitment to children’s science, mathematics, and technology education visible, and have your early childhood education and care centre, after-school centre, or primary school certified as a “Little Scientists’ House”. Application is easy: Just fill out the online questionnaire. With the certification plaque you receive, you can show the world: **“We are officially a ‘Haus der kleinen Forscher’ (Little Scientists’ House)!”**

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*The "Haus der kleinen Forscher" Foundation
wishes you lots of fun and success
in your joint explorations and investigations
with the children!*

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