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Thinking Inclusive Science Education from two Perspectives: Inclusive Pedagogy and Science Education

Lisa Stinken-Rösner, Lisa Rott, Sarah Hundertmark, Thomas Baumann, Jürgen Menthe, Thomas Hoffmann, Andreas Nehring & Simone Abels

Abstract

In the last decades, subject-matter education (Fachdidaktik) has been addressing the idea of inclusion rather incidentally. Although inclusive teaching and learning became more and more prominent in research and practice, a theoretical scheme combining inclusive pedagogy with respective subject-specific characteristics is still missing. This article by members of NinU („Netzwerk inklusiver naturwissenschaftlicher Unterricht"/"Network Inclusive Science Education") focuses on this challenge with science as an exemplary subject. To systematically combine the two perspectives, the article presents selected and significant characteristics of inclusive pedagogy and science education, before a scheme is suggested adjoining the two perspectives. NinU itself, as well as the presented scheme, can serve as a successful example of cooperation beyond disciplinary boundaries. Educators of other subjects are invited to identify significant aspects of their own subject that could be brought together with inclusive pedagogy in the same manner.

Keywords

Diversity, Goals of Science Education, Inclusion, Participation, Scientific Literacy for All

1 Introduction

Inclusion is one of the main topics which has been recently discussed in all subject-matter education disciplines (Fachdidaktiken) (GFD, 2015). However, these discussions are often limited to the perspectives of the subjects. A dialogue between domains of inclusive pedagogy and specific subjects rarely occurs. In the field of science education, for example, only a few studies and publications focus on the relation of inclusive pedagogy and the subject (Abels, 2015; Menthe & Hoffmann, 2015; Rott & Marohn, 2015; Scruggs, Mastropieri, Berkeley, & Graetz, 2010). Up to now, a scheme which systematizes and combines aspects of inclusive pedagogy and science education is still missing.

In order to bring different disciplines and experts together and to enable an interdisciplinary exchange, NinU („Netzwerk inklusiver naturwissenschaftlicher Unterricht"/"Network Inclusive Science Education") was founded in 2016. NinU is a collaboration of inclusive pedagogy and science education experts (primary science as well as biology, chemistry and physics education), which pursue a common vision of inclusive science education: "Science education contributes successfully to inclusion by supporting all learners – while appreciating their diversity and their learning prerequisites – to participate in individualized and collaborative subject-specific teaching-learning processes for the development of scientific literacy" (Walkowiak, Rott, Abels & Nehring, 2018, p. 270).

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The following remarks are intended to summarize discussions and reflections of NinU concerning the interplay of inclusive pedagogy and science education. Within several meetings during the last years we discussed different approaches towards inclusion and developed an agreement on terms and definitions to create a basis for further debates.

For this purpose, the central aspects of inclusive pedagogy and science education, that are significant for the interplay "inclusive science education", are described individually at first (Sections 2 & 3). The following integration of both perspectives results in a scheme illustrating the interplay. Examples of how the scheme can be used as support for lesson design are presented (Section 4). A more detailed discussion of possible applications for lesson planning and the location of research projects within the scheme will be presented in the following publications written by NinU members (Section 5).

2 Perspective of Inclusive Pedagogy

Inclusion and inclusive teaching by definition do not exclude anyone from education. On the contrary, exclusion means the missing or limited participation in education, cultures and/or communities (UNESCO, 2005). The political enactment of the Convention on the Rights of Persons with Disabilities (UN-CRPD, 2006) promoted a public discussion about inclusive education, which considers the different motives, learning conditions and developmental conditions. Thus, inclusive pedagogy does not only focus on the diversity dimension 'ability', but takes – in a wider perspective – all dimensions into account that people differ in, e.g., gender, age, culture, ethnicity, socio-economic background, religion etc. (Ainscow, 2007). The aim of this article is to derive a scheme that unites the normative and professional demands of inclusive pedagogy with the goals of science education. The elaboration of the inclusive perspective and its aspects should make it possible to present points of reflection which are important for the realization of inclusive science education. In the presentation of significant aspects, it becomes apparent that they create a field of tension between individualization and commonality, inclusion and exclusion and that, in some cases, aspects are also contradicted. When filling in the scheme, these normative goals should be seen as reflection points and will be discussed in section 4. In order to address the diversity and different needs of all students and to enable full and equal participation, barriers must first be recognized in order to be minimized or avoided. Additionally, in an educational sense, participation is about collaboration and creating different ways or approaches to a particular learning object. The perspective of inclusive pedagogy (Fig. 1) in terms of acknowledging diversity, recognizing barriers and enabling participation is explained below.

Figure 1: Perspective of Inclusive Pedagogy

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Acknowledging Diversity

Students are often addressed as homogenous learning groups. However, different dimensions of social inequality such as socio-economic background, ethnicity, gender and ability adversely affect students' learning opportunities. At the same time, it is obvious that every student has a unique personality, which is influenced by his*her individual biography or everyday experiences and determines his*her individual learning conditions and pathways (Taber & Riga, 2016). Even though some of these experiences may be traumatic, every student has potentials which can be used positively. In order to enable learning in diverse groups, potentials must first be recognized and respected without any discriminating effects (Booth & Ainscow, 2016; Florian & Spratt, 2013; Mastropieri & Scruggs, 2014). The diversity of a group is to be seen as a resource and a chance for individual and mutual learning processes and as an essential aspect of human development since this productive viewpoint opens up new perspectives for action (Florian & Spratt, 2013; Sliwka, 2010). Thereby, Florian and Spratt (2013) posit that learning and the experiences of individual students can be enriched in the sense of (co-)constructivism, as they profit from each other's experience in cooperative activities. These aspects can be useful by designing joint learning situations.

Recognizing Barriers

Inclusive education offers opportunities for individual and mutual learning, but also poses challenges for students and teachers. One challenge is the design of learning opportunities that do not involve exclusive elements. Barriers for learning can arise in the interplay between the learner and the learning environment. It is not solely the learner who creates or brings in barriers (Price, Johnson & Barnett, 2012; Scruggs & Mastropieri, 2007; Stefanich & Hadzigeorgiou, 2001; Stefanich et al., 2001). Florian and Black-Hawkins (2011) recommend to design learning opportunities that enable participation and self-determination. Using a differentiated task that allocates specific difficulty levels to only some students might, again, result in discrimination. As a consequence, Florian and Black-Hawkins (2011) conclude that teachers should focus on what is to be taught (and how) rather than who is able (or not able) to learn it. However, non-discriminating learning opportunities are difficult to develop and need to be checked for potential barriers for specific groups of students. Therefore, the first step towards minimizing barriers is to raise awareness for the fact that barriers can result from the interplay between the learner and the learning environment and for the possible obstacles itself.

In the following, a selection of possible barriers is described in more detail. These presented obstacles are not exhaustive. They should, however, show which aspects of the normative claim "recognizing barriers" can be important by filling the scheme.

Social and Language Barriers: Although academic achievements are potentially attainable by most children, the varying outcomes – as shown in PISA or TIMMS – demonstrate immense differences in the accessibility of education to specific student groups as well as to the degree to which circumstances permit them to benefit of those opportunities (Lee & Luykx, 2007). The main predictor for academic achievement and grades is the socio-economic status, e.g., general family income, parents' education or home atmosphere (Lee, 2005; Lee & Luykx, 2007; White, 1982).

Furthermore, effective teaching and learning requires a common language for the communication, understanding and development of accurate concepts. The communication among peers and between students and teachers is crucial. Compared to everyday language, the language of schooling is due to its formality and precise terminology unfamiliar to many students (Markic & Childs, 2016). Additionally, the same terms often have different meanings in the academic, the teaching and the daily language of the students (Childs & Ryan, 2016; Childs, Markic & Ryan, 2015; Stefanich et al., 2001). Students tend to mix daily and academic language and have difficulties in reading technical texts. Therefore, "language is a major barrier (if not the major barrier) to most pupils' in learning subject-specific content (Wellington & Osborne, 2009, p. 2), regardless of their abilities.

Cognitive Barriers: Another possible barrier is formed by the content itself or conception to be learnt, especially when students hold other conceptions. The more complex or abstract a content is, the higher is the possibility of it being a barrier for learning. Studies show that the development of certain conceptions proceeds quite similar for all students (Rott & Marohn, 2018). Students' understanding and thus their individual conceptions are based on everyday experiences (Lee & Fradd, 1998) and shape the interpretations and explanations of phenomena, which are often incongruent with the scientifically accepted conceptions (Chandrasegaran, Treagust & Moderino, 2008; Treagust, Duit & Nieswandt, 2000; Wandersee, Mintzes & Novak, 1994). The idea of merely replacing students' conceptions through the scientifically accepted ones is thereby seen as ineffective (Posner, Strike, Hewson, & Gertzog, 1982; Özdemir & Clark 2007). Teachers need to conciliate between learners and content.

Teaching is the most important motor of conceptual development at school age (Siegler, Eisenberg, DeLoache, Saffran & Gershoff, 2017), but can also become a barrier, for example, if students are over- or under-demanded or if teaching is restricted to certain forms of acquirement (McGinnis, 2013). Teaching means among others to support students developing an adequate understanding, which is especially challenging for students who require close guidance (Stefanich et al., 2001) or who need more support in phrasing their understanding (Rott & Marohn, 2015).

Affective Barriers: Interest and motivation are important for subject-specific learning. Accordingly, a lack of interest or motivation can be a barrier. General interests depend on gender, age, socioeconomic background or physical abilities (Gottfried, Fleming, & Gottfried, 2001; Jansen, Lüdtke, & Schroeders, 2016). Situational interest on the contrary is temporary and triggered by the current environment. Similarly, motivation can either be seen as internal (e.g. by interests) or external (e.g. by the situation, grades or rewards) (Ryan & Deci, 2000). Newer studies also show that individual interest is not a cause, but a consequence of knowledge gain (Höft, Bernholt, Blankenburg, & Winberg, 2019; Rotgans & Schmidt, 2017).

Physical Barriers: Schools are commonly not barrier-free. Many schools have, for example, difficulties to provide access for people in wheelchairs, or the necessary equipment for students with a visual or hearing impairment. Science laboratories and specific rooms like computer labs are mainly furnished with inflexible, screwed furniture. Typically, the setting is teacher-centered and expresses authority (Foucault, 1980). Furthermore, science classroom activities often also need potentially risky materials like Bunsen burners or harmful substances.

As mentioned before, the list contains a selection of possible barriers which can be relevant for inclusive science teaching. It can help to raise a first awareness for different obstacles which need to be recognized, before they can be minimized or avoided in order to enable participation.

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Enabling Participation

Recognizing and then minimizing barriers to learning is a prerequisite for participation, but also challenges the development of new approaches and, in particular, the phrasing of learning objects. The discourse on participation in the context of social inclusion and inclusive education is based on the human rights approach. “Participation in education involves going beyond access. It implies learning alongside others and collaborating with them in shared lessons. It involves active engagement with what is learnt and taught, and having a say in how education is experienced. But participation also involves being recognized for oneself and being accepted for oneself” (Booth, 2003, p. 2). Full participation and social inclusion include “rights *to* education”, “rights *in* education” and “rights *through* education”. According to this, education must be available, accessible, acceptable and adaptable (Tomaševski, 2001). Considering this and teaching students accordingly means to consider teaching towards different goals, individual promotion and the development of special approaches. Enabling participation implies to give students the chance to co-determine the content and to consider their individual ideas, interests or abilities as fruitful. Open learning approaches with self-determined processes and differentiation achieved through choice of activity for everyone are in line with Booth’s definition of participation (Abels & Minnerop-Haeler, 2016; Florian & Spratt, 2013). Situations need to be created in which children cooperate and participate in processes of discipline specific co-construction (Rott & Marohn, 2018). Since each individual develops different interests and motivations, inclusive pedagogy should address a wide range of contexts and methods to which the students can relate.

3 Perspectives of Science and Science Education

Scientific literacy is a widely accepted aim of science education, but also a very “diffuse concept” (Laugksch, 2000, p. 71) that is “encompassing many historically significant educational themes“ (DeBoer, 2000, p. 582). Bybee (1997, p. 69) explains that “the phrase ‘Scientific Literacy for all learners’ expresses the major goal of science education – to attain society’s aspirations and advance individual development within the context of science and technology”. For the PISA 2015 framework the definition of scientific literacy was revised as follows: “Scientific literacy is the ability to engage with science-related issues and with the ideas of science as a reflective citizen. A scientifically literate person, therefore, is willing to engage with science-related issues in reasoned discourse about science and technology, which requires the competencies to explain phenomena scientifically [...], understand scientific enquiry [...], [and] interpret scientific evidence [...]” (Roberts & Bybee, 2014, p. 552).

Building on these definitions, NinU members emphasize that inclusive science education has to focus on *all learners* and their individual development. We propose that science educators have to choose which scientific context is stimulating and relevant for each learner. The aim is to offer opportunities for all learners by either delivering scientific knowledge for professional domains (Roberts, 2007) or in a broader sense for a critical global citizenship education (Sjöström, Frerichs, Zuin & Eilks, 2017). Contexts, content and methods must support a deeper understanding of the natural world or be connected to everyday living (DeBoer, 2000) on different levels and regarding different perspectives and biographical experiences. The four categories of learning goals in science teaching (reasoning about scientific issues, learning science content, doing science and learning about science, cf. Hodson, 2014) encompass the main ideas of scientific literacy and build a useful starting point for further differentiation regarding a “scientific literacy for all” (Bybee, 1997). Together with the previously described perspective of inclusive pedagogy (Fig. 1), they informed the second perspective of our scheme of inclusive science teaching and learning (Fig. 2).

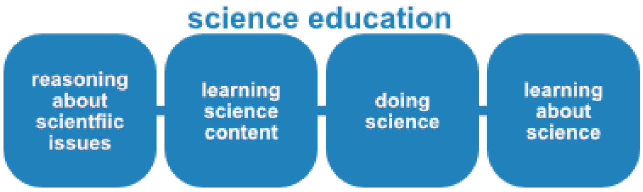

Figure 2: Perspective of Science Education

Reasoning about scientific issues

Scientific issues, addressed in inclusive science classes, must be stimulating and relevant for all learners, regardless of their future career. Regarding the first goal of science education (cp. Hodson, 2014) teachers can draw on individual interests, preconceptions and experiences in order to make science relevant. They can also choose special and fascinating phenomena to create a context that stimulates all learners to engage in science learning (Höft et al., 2019). In addition, the curriculum itself is a legitimation to select a certain scientific issue. However, it needs to be clear that an issue is not a content, but to be understood as a broader context for engagement. Additionally, reasoning refers to the development of a critical awareness of personal, social, economic, political or moral-ethical aspects of scientific issues (Hodson, 2014). Addressing (socio-)scientific issues also aims to support students' ability to reflect political and individual decisions (Sjöström, 2013). Environmental, political, social, or historical contexts can help students to become active and reflective citizens. Therefore, the first step towards a "scientific literacy for all" is the identification of stimulating and relevant scientific issues, contexts, problems and questions.

Learning science content

The second goal refers to the individual processes of developing a conceptual understanding. Scientists observe and work with visible and tangible objects and phenomena. Often, explanations of these phenomena involve assumptions about underlying processes that cannot be observed directly. Switching between observable phenomena and explanations is considered as a typical obstacle towards conceptual understanding for many learners. Problems in understanding will occur if science teachers are not explicit about the addressed level of thought (Schneeweiß & Gropengießer, 2019). Implicitly switching between levels (Abels, Koliander, Plotz, & Heidinger, 2018) or addressing all levels at once can result in cognitive overload for certain learners (Johnstone, 1991; Taber, 2013).

Science teaching must allow students to explore, modify and develop personal frameworks of understanding to gain scientific knowledge by building on pre-concepts and by "adding to, modifying and sometimes deleting elements from this complex of meanings and understandings" (Hodson, 2014, p. 2538).

Doing science

The third goal stands for using "specific [scientific] processes and procedures" like experiments (Hodson, 2014, p. 2546), which allow individual experiences. They provide opportunities for discovering objects, problems and phenomena for individual learners and groups. Doing science widens the range of activities in the classroom and offers all learners different practical and theoretical ways to engage with scientific phenomena and objects. The emphasis is not on learning about methods or techniques used by scientists, "but on using methods and procedures of science to investigate phenomena, test and develop understanding, solve problems and follow interests" (Hodson, 2014, p. 2545f.). Acknowledging diverse interests, abilities and varying expertise, different levels of guidance must be offered (demonstration of inquiry, guided practice and application (Hodson, 2014)).

Learning about science

The fourth goal refers to learning about the nature of science. In sciences and hence in teaching science, experiments and observations play an important role. One of the previously described learning goals is the understanding of scientific processes and the status of scientific knowledge. Lederman (2013, p. 833) stresses the significance of an adequate understanding of the nature of science that characterizes scientific knowledge as followed: "[it is] tentative [...], empirically based [...], and subjective [...]; [it necessarily] involves human inference, imagination, and creativity [...]; and [it] is socially and culturally embedded. Two additional important aspects are the distinction between observations and inferences, and the functions of and relationships between scientific theories and laws".

In order to realize these four goals, science teaching needs to address an "understanding of the nature of scientific knowledge, of the ways in which it is obtained, checked, and refined, and of the characteristics of sound arguments in support of a claim or conclusion about some aspect of the natural world" (Millar, 2006, p. 1507). That includes to "study the scientific enterprise and the activities of scientists" (Hodson, 2014, p. 2541) and an understanding of the interplay of science and society. That also means that science teaching is connected to other disciplines (e.g., historical and contemporary case studies, biographies of important researchers) and opens new and different learning opportunities (Hodson, 2014; Allchin, 2013). Teachers cannot address all four goals at once (Hodson, 2014). After choosing a relevant scientific issue, they need to decide about the focus of the lesson unit, is it conceptual, methodical, reflective or a combination of those.

Next to these, the scientific language and students' initial conceptions are strongly intertwined with all learning goals in science education. Therefore, they will be briefly highlighted.

Regarding language collecting data, reading graphs and expressing thoughts verbally, in writing as well as mathematically are necessary skills, especially for understanding science contents and for learning about the nature of science (Mastropieri & Scruggs, 2014; Price et al., 2012). Communicating in science contexts and learning to use scientific language correctly interrelates with all goals of science teaching. Both, Taber (2013) and Gibbons (2003), propose an increasing continuum of language in science classes, in which the focus shifts from the everyday language to the academic language during the learning process and which is initially achieved through different activities.

Besides language, students' individual conceptions have to be considered for all perspectives of science teaching and learning (Driver, 1981; Treagust, Duit & Nieswandt, 2000; Wandersee, Mintzes & Novak, 1994). The process of learning science should rather be seen as integrating students' ideas into conceptions adequate to the subject. Approaches like conceptual growth, change, reorganization or reconstruction are seen as helpful (Duit & Treagust, 2003; Sander, Jelemenská & Kattmann, 2006; Duit, Gropengiesser, Kattmann, Komorek, & Parchmann, 2012; Vosniadou 1999). Also, situational-socio-affective elements have an influence on the development of concepts (Pintrich, Marx & Boyle, 1993). Students benefit from motivational contexts, adequate learning instructions and collaborative learning processes in which they become aware, exchange and negotiate (individual) conceptions (Egbers, 2017; Hundertmark, 2012; Rott & Marohn 2018).

4 Inclusive Science Education

With regard to our vision of inclusive science education, inclusive science teaching and learning environments should impart scientific literacy with regard to the educational needs of each student. "Scientific literacy for all" can only be achieved when both, the inclusive (Fig. 1) and the scientific perspective (Fig. 2) as well as their respective subcategories are taken into consideration.

The combination of both perspectives leads to a scheme in the form of a cross table (Fig. 3a). Subcategories of the inclusive perspective are displayed as rows (yellow) and subcategories of the scientific perspective as columns (blue). The green area in between represents the interplay and thus, the idea of "Scientific literacy for all".

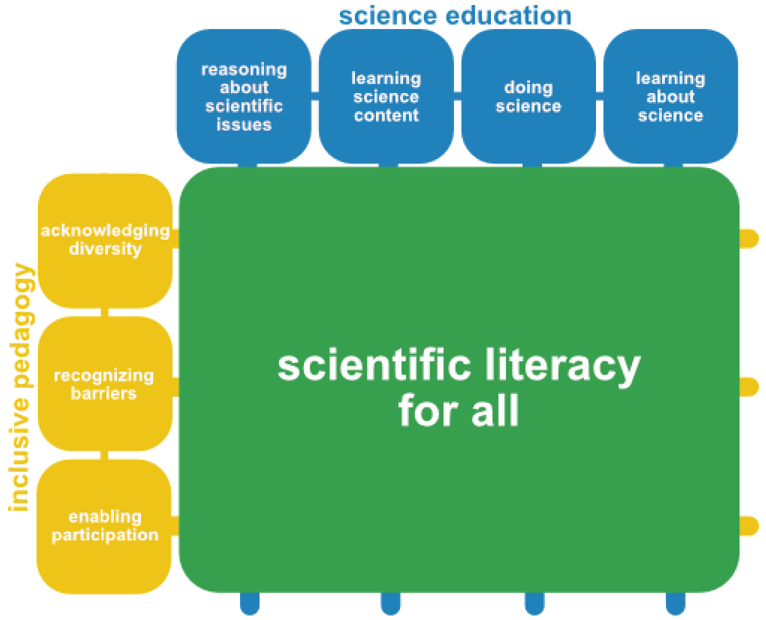

Figure 3a: Combination of the inclusive and the scientific perspective.

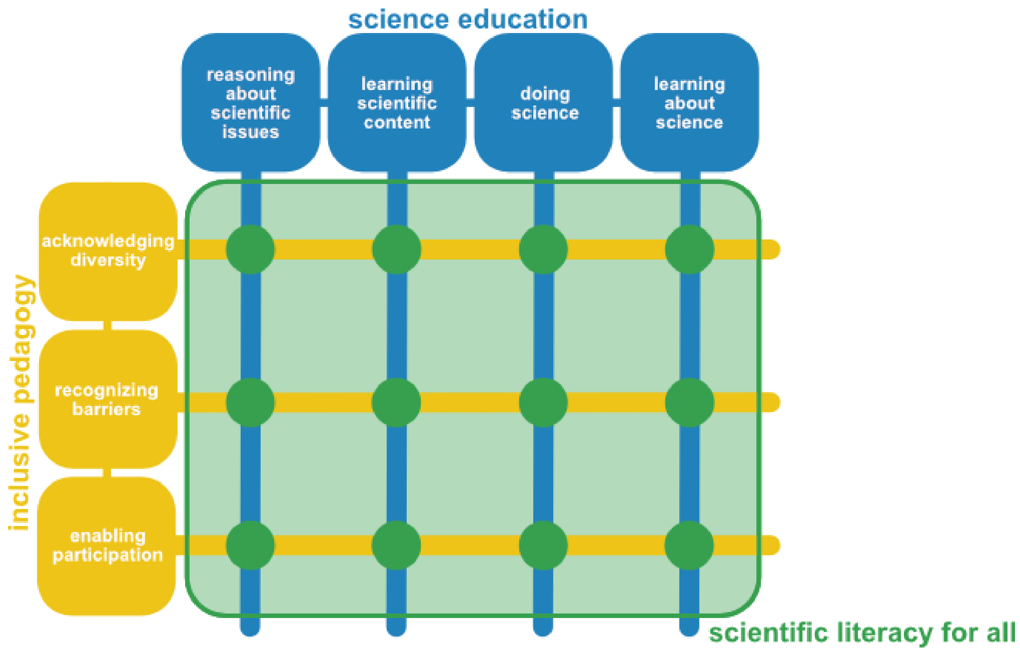

Figure 3b: "Scientific literacy for all" as an interplay of inclusive pedagogy and science education

However, inclusive science teaching and learning is more than just the sum of the individual perspectives. To realize “Scientific literacy for all”, the perspectives and their subcategories need to be understood as interwoven rather than as a homogeneous area (Fig. 3a). Each subcategory of inclusive pedagogy is linked to each subcategory of science education, and vice versa (Fig. 3b), as indicated by the green hubs.

Each hub of the scheme is filled with questions (Table 1), which are supportive when planning inclusive science lessons or analyzing research projects to get an overview in a certain field or identify research gaps.

Since the subcategories of both perspectives follow a certain reading direction, the resulting scheme can be read differently, but always starting on the top left side (I.A). Beginning to read the table in the first column (reasoning about scientific issues), the questions help to choose scientific contexts and issues, which are stimulating, relevant and accessible for all learners (I.A). Starting from here is mandatory to find a scientific issue that is addressing all learners. This issue or context should then be checked for further resources (I.A), barriers (II.A) and how participation can be enabled (III.A). The columns definitely have to be read from top to bottom considering the perspective of inclusive pedagogy. Not every question in each hub must thereby be relevant, however (Table 1).

Tab. 1: Relevant questions to support planning inclusive science lessons

	A. Reasoning about scientific issues	B. Learning scientific content	C. Doing science	D. Learning about science
I. Acknow-ledging diversity	1. Which **scientific issues** are stimulating and relevant for all learners?	1. Which **contents** are relevant for all learners?	1. Which **processes and procedures of doing science** are relevant for all learners?	1. Which **aspects of learning about science** are relevant for all learners?
	2. Which dimensions of diversity play a role in **reasoning about the scientific issue**?	2. Which dimensions of diversity play a role in **learning the scientific content**?	2. Which dimensions of diversity play a role for **doing science**?	2. Which dimensions of diversity play a role for **learning about science**?
	3. Which individual conceptions, skills and beliefs of learners are related to **(reasoning about) the scientific issue**?	3. Which individual conceptions, skills and beliefs of learners are related to **learning the scientific content?**	3. Which individual conceptions, skills and beliefs of learners are related to **doing science?**	3. Which individual conceptions, skills and beliefs of learners are related to **learning about science?**
	4. Which knowledge, skills and experiences of learners can be seen as resources for **(reasoning about) the scientific issue?**	4. Which knowledge, skills and experiences of learners can be seen as resources for **learning the scientific content**?	4. Which knowledge, skills and experiences of learners can be seen as resources for **doing science**?	4. Which knowledge, skills and experiences of learners can be seen as resources for **learning about science**?
II. Recognizing barriers	1. What are barriers and/or challenges for learners when **reasoning about the scientific issue?**	1. What are barriers and/or challenges for learners when **learning the scientific content?**	1. What are barriers and/or challenges for learners when **doing science**?	1. What are barriers and/or challenges for learners when **learning about science**?
III. Enabling participation	1. How can **(reasoning about) the scientific issue** be made accessible to all learners?	1. How can **(learning) the scientific content** be made accessible to all learners?	1. How can **doing science** be made accessible to all learners?	1. How can **learning about science** be made accessible to all learners?
	2. How can the existing resources be used to overcome the barriers or challenges when **reasoning about the scientific issue?**	2. How can the existing resources be used to overcome the barriers or challenges when **learning the scientific content?**	2. How can the existing resources be used to overcome the barriers or challenges when **doing science**?	2. How can the existing resources be used to overcome the barriers or challenges when **learning about science**?
	3. How can all learners be actively engaged when **reasoning about the scientific issue**?	3. How can all learners be actively engaged when **learning the scientific content?**	3. How can all learners be actively engaged when **doing science?**	3. How can all learners be actively engaged when **learning about science?**
	4. How can (all) learners be encouraged to co-construct and collaborate when **reasoning about the scientific issue?**	4. How can (all) learners be encouraged to co-construct and collaborate when **learning the scientific content?**	4. How can (all) learners be encouraged to co-construct and collaborate when **doing science?**	4. How can (all) learners be encouraged to co-construct and collaborate when **learning about science?**
	5. How can all learners be individually supported when **reasoning about the scientific issue?**	5. How can all learners be individually supported when **learning the scientific content?**	5. How can all learners be individually supported when **doing science?**	5. How can all learners be individually supported when **learning about science?**

Depending on the purpose (lesson planning, analysis of research projects etc.), users of the table may switch between columns after addressing hub I.A. Teachers, for example, may think about how a certain content associated with the context is relevant for all learners before they further reflect on the barriers. According to the aim of the teaching unit, not every column (B-D) may be relevant as the lesson may not be practical or learning about science is not addressed. Vice versa one of these aspects could be the main teaching goal, so that after column A only C may be of interest. The questions in the columns B and C help to identify the scientific content (learning scientific content) and the necessary scientific processes and procedures (doing science), which are relevant in relation to the scientific issue. Questions gathered in the last column (D: learning about science) can support addressing the nature of science in inclusive learning groups. Especially learning about science is often linked closely or even integrated in learning scientific content or doing science.

Even if some of the questions in table 1 are quite similar in multiple cells, answers can differ enormously. For example, possible barriers, like listed previously in section 2, depend strongly on the respective perspective of science education. When deciding on the context one might recognize social and language barriers, in contrast, when choosing scientific processes and procedures physical barriers can play an important role.

Nevertheless, the similarity of questions can help teachers to work with the scheme systematically and to develop a certain routine when using it.

To exemplify the usage of the scheme and table as support for lesson planning, we introduce a short example here about teaching science in a diverse classroom. Further ideas can be read in upcoming publications of NinU (Section 5). Following our suggestion, the planning process ideally starts with a stimulating and relevant context.

Contexts for teaching and learning can be found for example in everyday life, news or media. Teachers need to see the world with open eyes and in a sense also through the eyes of students to identify phenomena, which are stimulating and relevant for all learners. They may rest on an everyday life situation, for example, two children brushing their teeth in front of the washbasin. They battle for the small spot on the “warm” mat as their feet get cold, when they stand on the tiles.

Regarding the questions in column A (Table 1), this context is relevant as in everyday life most learners across most diversity dimensions experienced that various materials or surfaces feel differently, even if they have the same temperature (thermal conductivity) (hub I.A). Furthermore, all learners hold knowledge, skills or experiences about the situation described which can be seen as resource to access the underlying content ‘thermal conductivity’ (I.B). For example, many learners are familiar with the term temperature and some know how to use a thermometer. This can be used as a resource to raise awareness of the difference between temperature and individual sensation.

Possible barriers or challenges regarding the context (II.A) might be that some learners do not have this experience e.g., due to paraplegic or because they have a heated bathroom floor in their home.

However, the context can be made accessible to all students with only minor changes (III.A). Thermal conductivity is also evident in other everyday situations, e.g. the cutlery feels colder than the table, sitting on a metal chair feels colder than on a wooden bench or water (at room temperature) feels colder than the air in the room itself. The question is always: How can the context be made accessible to all due to individual experiences or relevance?

At this point of the planning process, we again turn to the science content that is related to the chosen issue (column B). Which relevant scientific content is related to the scene of the “cold” floor? The “cold” tiles and the “warm” mat refer to the concepts of heat, of temperature differences, of heat dispersion and the concept of thermal conductivity. Usually, there will be no strict separation of the planning of context and content: while thinking about appropriate contexts, related content will simultaneously emerge and vice versa. Teachers often have curriculum-based content and a related context in mind that they usually teach. These contexts have to be checked along Table 1 to see if they are really appropriate for the diversity of the group (column A). To avoid this rather classic approach, we are in favor of choosing a stimulating context first and check it for basic content.

Reassessing the adequacy of the content as “science for all” might result in further adaptations: Are all aspects of the concept of thermal conductivity equally relevant to all learners? Here, an adaptation regarding a concrete learning group and particular students will be necessary. Scaffolding, demonstrations and experiments with different objects (different materials with the same temperature, same and different objects at different temperatures) and the usage of visualizations and appropriate models have to be chosen in order to find the best fit regarding skills, knowledge and experiences of the individual learners. To make the content accessible, different representations (and theoretical as well as practical experiences) around the phenomenon can be offered. One observation could be that the mat and the tiles have the same temperature, but feel differently.

Typical barriers (II.B) in this case might be that learners have difficulties to understand the differences between the relevant terms and concepts. How can the difference between heat and temperature be explained? How can the difference between the temperature and the individual sensation of materials that feel warm or cold be explained? Students conceptions as described by the classical work of Tiberghien (1980) regarding concepts of heat and isolation (melting of an ice cube that is packed in different materials) might on the one hand be a barrier towards understanding (II.B), on the other hand, these conceptions can be seen as a resource for doing science (I.C): learners will have ideas and hypotheses that can easily be tested in the laboratory. The different views and opinions open space for collaboration and joint experiences (III.C). The chosen example allows a lot of “doing science” as no toxic or dangerous experiments are needed and the complexity of the experimental setup can easily be adapted to the learning group (column C).

By using the scheme (Fig. 3b) and the table (Tab. 1), it becomes clear that the “warm” bath mat can be used as a stimulating and relevant context for all students with only little adaptations. Teaching goals for individual lessons can be developed following the columns B to D.

5 Summary and Future Directions

In this paper, we emphasized that inclusive subject-matter education calls for new theoretical approaches. These approaches cannot be derived from just one discipline or the subject itself. It is rather a combination of different aspects of inclusive pedagogy and subject-matter education (here science education). Nevertheless, we renounce from a detailed discussion of the interplay at this point, since this is mainly relevant for science education disciplines. A detailed discussion of the application of the presented scheme to support lesson planning and the location of already existing research projects as well as the identification of research desiderata with the help of the scheme will be the focus of the next NinU publications. A paper explicating how to plan lessons with the scheme is in preparation for the special issue “Science Education and Inclusion” in the journal “Sonderpädagogische Förderung *heute*” (Special Education *today*). Here an example of how to work with the scheme and the table in science education is presented in much more detail. A paper on how to apply the scheme and the table for research is in preparation as well.

By presenting the results of our NinU discussions and reflections, we want to encourage educators of other subjects to start thinking inclusive subject-matter education from two perspectives by adapting the scheme in accordance with the significant perspectives of their subjects.

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Lisa Stinken-Rösner
is a researcher at the Leuphana University Lüneburg. Her research areas are inclusive science education, digital media in science education and measurement estimation.

Lisa Rott
is a researcher for chemical education at the Westfälische Wilhelms- Universität Münster. Her research areas are inclusive science education and especially collaborative learning and conceptual development in inclusive classes.

Sarah Hundertmark
is a researcher at Leibniz University of Hanover. Her research interests are collaborative learning in the context of students' conceptual development, inclusive teaching through multiprofessional teams and chemistry learning through productive failure situations

Thomas Baumann
currently works as a trainee teacher at a secondary school in Dortmund. During his doctoral studies he dealt with the digitisation of learning materials with regard to inclusive students

Jürgen Menthe
is a professor for chemistry education at the University of Hildesheim.

Thomas Hoffmann
is professor for inclusive education (focus: disability) at the University of Innsbruck. His research areas are inclusive didactics (focus: chemistry didactics), education and rehabilitation of children with developmental disabilities and disability history.

Andreas Nehring
is a professor for chemistry education at the University of Hannover.

Simone Abels
is a professor for science education at the Leuphana University Lüneburg. Her research areas are inclusive science education, inquiry-based learning and reflective teacher education.