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Inaugural Issue:

Welcome to DILeMa

Digital Inlusive Learning Materials (DILeMa)

Contents

EDITORIAL

First Issue

Vol. 1 No. 1 (08/2025): Contributions to the thematic focus Digital Inclusive Learning Materials. Teaching and learning materials (DILeMa)

Dear readers,

Welcome to the inaugural issue of *DILeMa – Digital Inclusive Learning Materials*, a peer-reviewed online journal dedicated to advancing research and scholarship at the intersection of digitalization and inclusion in educational resources. This journal emerges from the ongoing *Erasmus*+-funded project *digiLLM*, which explores the inclusive potential of Open Educational Resources (OER) and digital learning materials more broadly. DILeMa offers an open-access platform for academics, teachers, and learners to critically engage with the design, use, and implementation of inclusion-oriented digital materials across diverse educational contexts. By actively involving students, researchers, and practitioners, DILeMa seeks to foster a new model of scholarly communication that transcends institutional hierarchies and brings together a wide range of stakeholders in pursuit of a shared goal: identifying and disseminating best practices for inclusive digital education. In this way, the journal not only promotes informed discourse on digital learning materials and inclusion but also serves as a pedagogical tool supporting collaboration, reflective practice, and continuous learning across all stakeholder groups.

This discourse is developed through three types of contributions. *Section I: Scientific Articles* combines theoretical and empirical research, including systematic literature reviews, on digital learning materials. *Section II: Meta-reviews* provides practice-based, meta-level analyses of digital educational resources and their potential to support inclusion. These meta-reviews are undoubtedly a scientific format, but their referencing of existing reviews also makes them especially conducive to involving junior researchers. They allow multi-perspective evaluations using specific reflections tools like the *Framework for the Reflection on Living Learning Materials* (FRoLLM) to enter into the academic discourse. In addition, meta-reviews provide valuable feedback for content creators and platforms alike. This section is therefore closely linked to the digiLLM project's portal and draws on over 300 reviews conducted by teachers and teacher education students in the Czech Republic, Germany, Luxembourg, and Sweden. For future issues of DILeMa, please note that reviews of published meta-reviews are always welcome. They create open participatory spaces for practitioners to share their opinions and experiences. *Section III: Discussion Papers* offers critical reflections on questions of education, policy, and society, connecting ongoing and emerging debates in the field.

Further information on the digiLLM project and the reviews can be found at:
https://digi-europe.org/

About this Issue: A Brief Overview

This inaugural issue brings together ten contributions exploring topics such as inclusive teaching competencies and the use of digital learning materials in fostering inclusive learning environments.

Section I: Scientific Articles

The first article, **"Linking Competencies for Inclusion and Digitalization in Teacher Education: Theoretical and Conceptual Foundations of the Learning Concept inklud.nrw"** by *Jana Herding, Petra Büker, Anna-Maria Kamin,* and *Franziska Schaper*, introduces the OER-based teacher training program inklud.nrw. It explores how the program equips pre-service teachers with the knowledge and skills to design inclusive teaching concepts using digital media, integrating reflective methods and quality-assured OER materials.

In the second scientific article, **"The Intertwining of Inclusive and Digital Learning. A Scoping Review on Digital Learning in Inclusive Science Education"**, *Katja Andersen* investigates how digital learning tools have been used to support inquiry-based learning in inclusive science education from 2014 to mid-2024. With a focus on primary education, the article investigates how digital materials are integrated into teaching practices to foster inclusive learning environments. Andersen finds that much of the existing work emphasizes support for gifted students, while significantly less attention is paid to learners with special educational needs. The study also identifies promising teacher training approaches that combine inclusive pedagogy with digital tools.

The third scientific article, **"Developing and Creating Inclusive and Interactive Digital Reading Environments—with and for Students with ADHD"** by *Josefine Karlsson* and *Anette Bagger*, focuses on a digital learning tool that can be designed and adapted to support reading acquisition for students with ADHD in a sustainable, inclusive, and effective way. The authors advocate for integrating inclusive education with digital reading strategies, specifically in the case of students with ADHD. The article provides practice-oriented design principles for creating both technically and pedagogically inclusive digital learning materials.

Section II: Meta-reviews

FRoLLM… what's that? Before introducing the six meta-reviews featured in this section, we would like to provide a brief overview of the *Framework for the Reflection on Living Learning Materials* (FRoLLM). This framework was developed to support the inclusive design of teaching and learning materials, taking into account the diverse needs of learners. It also served as the basis for the reviews analyzed in this section. FRoLLM outlines six key areas of reflection that are essential for understanding, using, and developing inclusive digital learning materials. These six areas are: Philosophy, Learners' Reflection on Learning, Learners' Needs, Learners' Environment(s), Learning Feedback for Learners, and Learners' Agency. Each of these areas provides a range of questions that encourage the reflection of the level of inclusion-orientation. Additionally, the FRoLLM contains questions about open access requirements and requests a final assessment of the material in terms of inclusivity.

The framework is available for download as a PDF in multiple languages on our project website. In the complete edition of this inaugural issue of DILeMa, we also present the English version of the worksheet as a PDF template. Developed as a research-based evaluation tool, FRoLLM draws on a combination of empirical data and literature review, including interviews with teachers, teacher educators, and student teachers, as well as prior research on learning material evaluation and existing assessment models.

The first meta-review, **"Astro Pi Mission Space Lab – A Meta-review of Science Education Learning Material"** by *Katja Andersen* and *Frederic Conrotte* (Luxembourg), is based on five reviews of the Astro Pi

materials. The analysis explores how these resources allow students to engage with space exploration and coding, highlighting their potential to inspire inclusive teaching practices in innovative, future-oriented educational contexts. At the same time, the meta-review identifies specific areas for improvement to better support diverse learners.

In the second meta-review, **"Interaktives Tafelbild – Symmetrie: Meta-Review eines Lernmaterials für den Mathematikunterricht"**, *Vivienne Uffmann (Germany)* reflects on an interactive math tool that was reviewed six times. The material incorporates real-life examples and offers an engaging approach to teaching symmetry. Although the analysis reveals significant shortcomings across nearly all FRoLLM dimensions, it also indicates that the material holds potential. With targeted adaptations, it could serve as a basis for developing more inclusive teaching practices in mathematics.

The third meta-review, **"Magrid: A Meta-review of Learning Material Evaluations"** by *Anette Bagger (Sweden)*, examines Magrid, a digital learning tool designed for early learners and students with special educational needs. Based on three reviews, the analysis explores the extent to which Magrid supports its target learner groups, drawing on theoretical foundations of inclusion and the application of the FRoLLM framework.

In the fourth meta-review, **"Biology in Context. Meta-review of Learning Material Evaluations"**, *Iva Červenková, Tereza Vašutová,* and *Michaela Černíková (Czech Republic)* assess a Czech biology textbook. While this textbook demonstrates certain strengths, five reviewers agree that it cannot be considered an inclusive teaching resource due to low ratings across the FRoLLM dimensions. Nevertheless, its positive aspects offer a useful foundation for developing more inclusive approaches to science education.

Henrike Raschkowski (Germany) contributes the fifth meta-review, **"Interaktives Tafelbild: Wie die Welt zusammenwächst – Meta-Review eines Lernmaterials für den Sachunterricht"**. Applying the FRoLLM framework to a package of OER teaching and learning materials, she draws on four reviews to systematically highlight the strengths and weaknesses of the material. This article illustrates how, despite existing gaps regarding inclusion sensitivity, OER can be individually adapted by teachers to promote inclusion.

Finally, **"The 'Project 2' English Language Textbook for Lower Secondary Schools – Meta-review of Learning Material Evaluations"** by *Nikol Porubová* and *Iva Červenková (Czech Republic)* evaluates an English textbook within the context of the current Czech curriculum reform aimed at raising language proficiency. Through the FRoLLM lens, the authors compare three reviews of the learning materials and identify both strengths and weaknesses in its approach to inclusion.

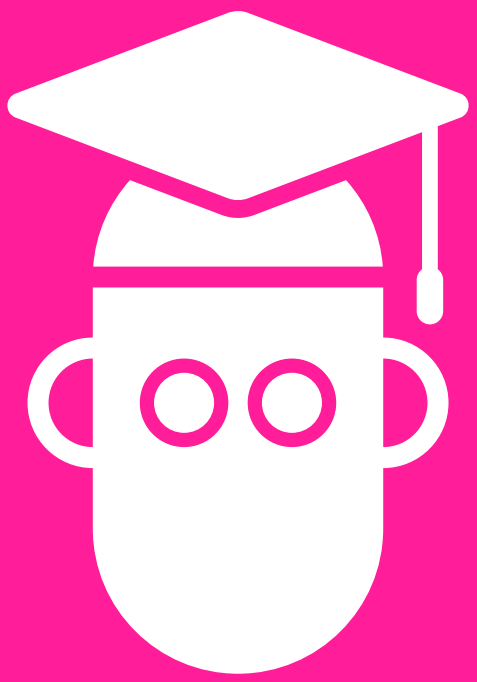
Section III: Discussion Papers

The issue concludes with **"Imaginaries of Openness in Education"** by *Markus Deimann*, which explores the narratives surrounding OER, AI, and cyber-utopianism. Deimann discusses three key "imaginaries" of openness and argues for rethinking educational relationships, promoting greater inclusion, and updating regulations to support AI-enabled OER remixing.

Together, these contributions offer a multifaceted perspective on current research and practice in digital inclusive education. They encourage readers to critically reflect on existing paradigms, explore new approaches, and further develop their own professional perspectives on the upsides as well as the limitations of digital inclusive learning materials.

On behalf of the editors, we hope you enjoy reading this issue and find it a source of inspiration for teaching, research, and reflection.

Michaela Vogt, Katja Andersen, Annette Bagger, Zuzana Sikorová, and Stefanie Go.



Section I:
Scientific Papers

Linking Competencies for Inclusion and Digitalization in Teacher Education:

Theoretical and Conceptual Foundations of the Learning Concept inklud.nrw

Jana Herding, Petra Büker, Anna-Maria Kamin & Franziska Schaper
Paderborn University; Bielefeld University

Abstract:

The acquisition of competencies related to inclusion and digitalization represents a current cross-sectional task in teacher education. In schools and universities, these two areas have not yet been systematically interwoven, despite the expected synergies for both university students and future teachers. Professionalization programs that effectively integrate inclusion and digitalization are thus needed. The project *inklud.nrw* achieves this by using the case study method to create a teaching and learning concept for teacher education. It links inclusion and digitalization to ensure the full participation of all university students who (also) are trained to design their own inclusive teaching concepts with media. The article illustrates how such an innovative teaching and learning concept can be theoretically grounded and designed as an Open Educational Resource (OER). It elaborates the theoretical foundations of inclusion and digitalization, provides praxeological insights into the conceptual design of the *inklud.nrw* teaching and learning materials, and raises questions about quality assurance. The freely available OER for educational science teaching presented in the following article is especially designed for university students who want to become primary and lower secondary school teachers in Germany.

Keywords:

inclusion; digitalization; case studies; teacher training; professionalization

https://doi.org/10.11576/dilema-7626

1 Initial Situation in Teacher Education

School teachers are facing various challenges, from the heterogeneous learning and developmental conditions of children and adolescents to the need to digitally support teaching, learning, and media education. Accordingly, inclusion and digitalization constitute two cross-sectional issues in teacher education. Qualification programs, however, often treat them separately, leaving synergetic potential largely untapped. This renders a competency-promoting integration of these topics highly relevant for teacher training at universities. Germany's educational policy requirements for the school context (Bosse, 2019; Eickelmann, 2020) as well as for higher education follow international policy standards (UN-BRK, DigCompEdu as described by Redecker, 2017), but as a federal country, Germany also has country-specific policies for inclusion and digitalization.

Competencies for inclusion and digitalization can only be developed appropriately through a process of professionalization (Reiss et al., 2021; Tulodziecki & Grafe, 2020). Inclusion and digitalization are each highly complex, multifaceted constructs discussed in diverse and sometimes very controversial ways. Both are characterized by inherent tensions that need to be productively addressed in schools and universities (Büker et al., 2022a; Gryl, 2022). In recent years, inclusion and digitalization have also proven to be highly dynamic topics, with school practice exposed to significant development and action pressures, under which pedagogical solutions (must) emerge. Lecturers working in cross-disciplinary teacher training are asked to develop knowledge in the field of inclusion and digitalization, to implement an appropriate didactic course design for teacher training, and to establish bridges to school practice. Policy guidelines mandate that inclusion and digitalization form part of the curriculum in Germany's teacher training, attached to specific credits.

According to Záhorec et al. (2021, p. 2), the increasing diversity and rapidly evolving technologies make it essential to continuously innovate pre-service teacher preparation in order to foster the ongoing development of professional digital literacy. Therefore, there is a need to develop corresponding theory-based teaching/learning concepts that are useful for educators who work with student groups with various learning prerequisites and preferences. Appropriately aligned, scientifically based teaching/learning materials (TLM) can play a vital role in this endeavor. While teacher education research has, in recent years, highlighted the importance of cognitively activating learning tasks for the students' competence development, it has paid comparatively scant attention to the role of didactic TLMs. The COVID-19 pandemic, however, vividly showed that TLM quality plays a crucial role in students' learning processes. It is therefore essential to recognize that "technology can amplify great teaching but great technology cannot replace poor teaching" (OECD, 2015, p. 4). The integration and adaptation of digital technologies require new working methods for teachers as well as reflection on—and analysis of—the effects of digital media (Rodriguez, 2020, p. 24).

Consequently, university lecturers and researchers must take into account not only the materials but also the complex teaching/learning concept (including TLM and teaching/learning settings). This makes it even more important to examine how a quality-assured teaching/learning concept can be theory-driven and coherently designed, contributing to the synergetic and innovative linking of the cross-sectional tasks of inclusion and digitalization in teacher education. This is exactly where this article comes in.

Using *inklud.nrw*[1] as an example, this article discusses how inclusion, media education, and case studies can be theoretically and conceptually integrated to develop an open higher education didactic teaching/learning format. The aim is to help pre-service teachers acquire competencies related to inclusion and digitalization

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in heterogeneity-oriented modules, as well as to recognize synergies between both areas (Büker et al., 2021). This concept's general compatibility with the principles of Open Educational Resources (OER) is further discussed and examined.

In order to better understand the article's structure, it is important to clarify that the *inklud.nrw* materials' conceptual framework consists of four core elements. As a central content aspect at the intersection of inclusion and digitalization, the *inklud.nrw* teaching/learning concept conceptualizes the issue of (1) *participation*. Participation—understood as engagement in school and democratic practice—is normatively embedded in both inclusion and digitalization. The demand for (2) *reflection* is also inherent in both cross-sectional tasks. From a didactic perspective, the (3) *case study method* serves as the connecting element for the development of inclusion- and digitalization-related competencies. The overarching design principle is that of the (4) "*pedagogical double-decker*" (Wahl, 2013, p. 64, referencing Geissler, 1985, p. 8): Not only is the integration of inclusion- and digitalization-related content the *subject* of discussion, but the requirements derived from these competency fields have been incorporated into the design of the teaching/learning concept at university, thus creating *experiential quality* for the students.

This article shows how these four core elements have been theoretically well-founded and incorporated into OER. It first explains briefly the theoretical understanding of inclusion, digitalization and case study work that underpins the project (Section 2; see in detail: Büker et al., 2022b). This is followed by a presentation of the didactic structure and design of the open digital teaching/learning concept *inklud.nrw* for educational science in higher education (Sections 3 and 4). The conclusion (Section 5) addresses how the academic quality of (reflective) engagement with the complex demands at the intersection of inclusion and digitalization can be ensured—through the design of both the teaching/learning concept as an open educational resource itself and that of the courses in which the material is used.

2 Theoretical Foundation in the Context of Inclusion, Digitalization, and Case Study Work

Competency requirements related to inclusion

Inclusion has become a significant societal issue in recent years, especially since Germany ratified the *UN Convention on the Rights of Persons with Disabilities* in 2009, aiming to establish an inclusive school system that ensures participation in education and society for all (Prengel, 2012). Given Germany's traditionally segregated school system, which assigns students to specific school types based on individual needs, inclusion requires a complex reform process (Büker et al., 2022a). There are diverse understandings of inclusion across research, politics, municipalities, and schools, ranging from a narrow focus on students with and without special needs to a broader, intersectional view that seeks to de-categorize diversity (Emmerich & Moser, 2020). As of now, there is no political consensus on defining equitable participation in the education system (Hußmann et al., 2018).

Schools are the arenas where advocates, skeptics, and opponents of inclusion meet and must navigate structural challenges daily. Academic reflection is crucial for teacher professionalization, as emphasized by a 2015 joint recommendation from the Standing

[1] The collaborative project *inklud.nrw*—involving the universities of Paderborn, Bielefeld, Duisburg-Essen, and Siegen—was funded by DH-NRW as part of the OERContent.nrw funding line from 07/2020-12/2022. It aimed to create digital educational materials in the Open Educational Resource format (OER according to UNESCO, 2021), accessible to all universities on North Rhine-Westphalia's digital state portal ORCA and available for free reuse in the future. The digital teaching/learning concept developed here was tested and evaluated in educational science lectures and seminars at the partner universities. In this context, *inklud.nrw* closely interlinked the dimensions of content (inclusion, digitalization, inclusive media education), university media didactics (teaching and learning with media), and technology (developing an adequate, functional infrastructure) in terms of coherence (Büker et al., 2021). After the successful finalization of the project, the materials are now available as freely accessible educational resources: https://www.orca.nrw/oer/oer-finden/oer-bibliothek/inklusion-2-2/kk-inklusion-inklud-nrw/.

Conference of the Ministers of Education and Cultural Affairs (KMK) and the Conference of Rectors of Universities (HRK) in Germany. This recommendation encourages aligning teacher training with the concept of a "school of diversity," (p. 3) embedding diversity management across all disciplines, with a focus on inclusive education. Competence-oriented models have been developed to prepare future teachers for evolving pedagogical situations by linking theoretical knowledge with practical conditions (Reiss et al., 2020). This involves cultivating heterogeneity sensitivity, defined as the ability to perceive student diversity critically and recognize practices that create or reinforce social inequalities. This concept is central to the reflective inclusion approach, which views differences as social constructs that need deconstruction (Budde & Hummrich, 2013; Schmitz & Simon, 2018).

Digitalization-related competency requirements from the perspective of inclusion

Digitalization, a societal transformation process akin to mediatization, increasingly intersects with inclusion efforts, impacting education and media infrastructures (Krotz & Hepp, 2012). This transformation challenges societal structures and practices, particularly in digital education and learning environments (Bosse, 2019). The European Commission's Digital Education Action Plan (2021–2027) aims to enhance digital competencies and create a robust digital education ecosystem (European Commission, 2020). In Germany, the KMK emphasizes integrating digital learning to address heterogeneity and individualized learning (KMK, 2021).

Inclusive Media Education is proposed to intertwine media competence with equitable learning, facilitating participation in, with, and through media (Bosse, 2016; Kamin & Bartolles, 2022). Media representations influence societal diversity portrayals by potentially reinforcing stereotypes or enabling diverse perspectives (Bosse, 2019). Teachers must use digital media didactically to manage heterogeneous groups and foster media competence (Schluchter, 2014, 2015; Schulz, 2021).

Future teachers recognize the need for improved digital training to support inclusive education (Val & López-Bueno, 2024). Teachers must select, implement, and adapt media to create individualized educational opportunities, leveraging digitalization's potential (Bosse, 2019). They are encouraged to collaborate with extracurricular organizations for media-related support (KMK, 2016). Tulodziecki & Grafe (2020) and Záhorec et al. (2021) also state that continuous reflection and knowledge updating are essential for teachers' professionalization to equitably promote media education.

Case studies are used in the project *inklud.nrw* to support professionalization for inclusion and digitalization in teacher education, establishing a meaningful connection between these areas.

Case study work as a potential approach to connect inclusion and digitalization

Current discussions on professionalization for inclusion in teacher training and education attribute significant importance to case-based approaches (Fabel-Lamla et al., 2020). At university, case study work encompasses didactic approaches, "which focus on the action-relieved, intellectual examination of qualitative data material" (Kunze, 2020, p. 29f.). The general aim of case study work is to initiate a reflective habitus through profession-relevant issues linked to theoretical interpretative frameworks. Inclusion, digitalization, and case study work can thus be primarily connected through reflection (Büker et al., 2022b). Kunze (2020) distinguishes between a structurally theoretical, reconstructive case study approach on the one hand and a more pragmatically oriented, competence-focused approach on the other. The reconstructive case study approach tends to re- or deconstruct the case and to critically reflect its context. The pragmatically orientated approach, in contrast, tends to systematically find alternative

solutions or decisions for practice. Media-supported case study work is firmly established in teacher education through methods such as learning from video cases (Digel & Schrader, 2013) and integrating tools like forums or chats to provide enhanced interactivity. The project *inklud.nrw* uses reconstructive and pragmatic media-supported case study work in a new context, conceptualizing it as a connecting method for developing competencies relevant to both inclusion and digitalization.

3 Conceptual Decisions for the Teaching/Learning Concept *inklud.nrw*

The goal of the *inklud.nrw* open digital teaching/learning concept is to empower students to shape education in a digitally influenced world, ensuring active and independent participation for all, in accordance with the inclusion claim. To align with a comprehensive understanding of participation, *inklud.nrw* has chosen a broad understanding of inclusion for the development of such a concept. Accordingly, all dimensions of heterogeneity that may lead to disadvantages in terms of restricted participation in schools and society are comprehensively considered in the materials and tasks (Haberstroh et al., 2018). It therefore negates the sole reduction of the concept of inclusion to the differentiation line of disabled/non-disabled (Boban & Hinz, 2017) and includes inequality-generating categories such as gender, social background, language, and learning dispositions. A central objective is to sensitize future teachers with regard to the conditions of participation alongside the development of knowledge and skills. Inclusion research considers this a significant competency regarding "heterogeneity sensitivity" (Schmitz & Simon, 2018), as does the discourse on media education from the perspective of inclusion. The case examples for *inklud.nrw* are derived from the *Vielfaltstableau* (Universität Paderborn, o. J.).

The *Vielfaltstableau* is a German web-based training and education tool that offers a set of around 20 exemplary cases. It was originally developed by a multi-professional team of researchers, daycare educators, and teachers at both primary schools and schools for pupils with special needs. The authentic, anonymized cases portray the life and education of various children and adolescents with heterogeneous participation prerequisites, as seen from the perspectives of the respective case providers. The *Vielfaltstableau* contains teaching/learning tasks based on a broad understanding of inclusion, aimed at developing participation-oriented individual support in schools, as well as reflecting on prompts for biographically reflective engagement with the users' individual notions of normality. It follows a subjective-oriented approach, focusing on the child or adolescent while also adopting a systemic perspective in terms of an ecological multi-level model (Albers & Lichtblau, 2014). For maximum participation in the school context, the needs, resources, and perspectives of children and adolescents must thus take center stage—linked to a systemic view of the conditions and actors in their complex social environment (parents, peers, teachers, etc.).

inklud.nrw utilizes case study work for digitalization- and inclusion-oriented teacher education, with the "portraits" providing the learning opportunity. This is always linked to the reflective question of what/who constitutes a case, and how it is shaped by whom. Case studies are here broadly defined as "a case-oriented approach to learning, teaching, investigating, and researching, which focuses on educational processes in the context of school and teaching and is used for the purposes of illustration, analysis, reconstruction, decision-making, planning, development, and reflection" (Steiner, 2014, p. 8). Following the findings outlined in Section 4, a complex and diverse case format is offered that considers students' heterogeneous learning prerequisites, interests, and needs. Here, reflexive-reconstructive, decision-oriented, and practice-reflective approaches come into play, in line

with Steiner's (2014) classification. This allows various task types to facilitate both

- the reconstruction and critical reflection of educational science practices (in the research mode typical for inquiry-based learning), and
- the indicator-based analysis and development of design and action alternatives for heterogeneity-oriented teaching (in the training-related mode of building action competency).

Using case portraits, *inklud.nrw* aims for intensive learning engagement via one or more cases (case comparison). The teaching/learning concept provides the opportunity to develop a pedagogical-didactic focus in which the individual participation opportunities of the child/adolescent in school contexts are analyzed through diverse tasks (Section 4).

To enable reflective processes on media education from an inclusion perspective, alongside engagement with inclusion itself, the case portraits from the *Vielfaltstableaus* have been further developed into scenarios that consistently address participation in, with, and through media. On the one hand, this involves creating an extensive, media-supported, and largely accessible representation of the cases (including expert interviews, texts, images, and videos). These materials, combined with a media education concept, are integrated into a coherent teaching and learning framework. In line with the "*pedagogical double-decker*" (Wahl 2013), they are made tangible through media-supported teaching and learning experiences. On the other hand, the materials and tasks emphasize reflection on, and awareness of, the best possible (digital) participation opportunities for children and adolescents. This includes addressing topics such as media access, the acquisition of media competence, and representations of diversity in media within the tasks (for more detailed explanations, see Section 4).

At the forefront of this subject-centered and systemic case study work is the recognition of both visible and less obvious *barriers*, including digital ones, that can prevent successful inclusion (Wernet, 2006). Action and decision-making options based on both cases and theory are developed in the educational context while also adding questions for personal self-reflection, reflection on pedagogical practice, and meta-reflection on participation from the inclusion-and-digitalization perspective to every task setting. The materials also include elements of a practice-reflective or practice-analyzing case study approach (Schmidt & Wittek, 2019), allowing both educators and students to contribute their own scenarios and cases. Their intent can be defined as either *external* (focus on school and teaching) or *internal* (focus on individual development or professionalization, particularly through engagement with subjective theories and assumptions of normality) (Aufschnaiter et al., 2019). Both approaches are equally significant for the development of inclusion competence and media education.

In principle, tasks should be individually adaptive and enable collaborative social learning among students. The case-oriented, reflexive questions contained in the material pursue the goal of *reflective inclusion* (Budde & Hummrich, 2013). This means that they neither aim at the transmission of "recipes for direct action" (Hummrich, 2020) often desired by students nor focus on problem-oriented engagement with individual cases. Instead, critical analysis of the case material's limitations forms an important cross-cutting theme within the learning tasks. A case is first assigned through the selection and preparation of the children's and adolescents' portraits from the *Vielfaltstableau* by the developers of the material. In a second step, educators choose from these pre-selected and prepared cases. The assignment of significance for the identification of the case is thus multi-stage and predefined, representing a particular feature in the project context that must be deconstructed in the manner of a possibly reduced presentation (Stets & Vielstädte, 2022).

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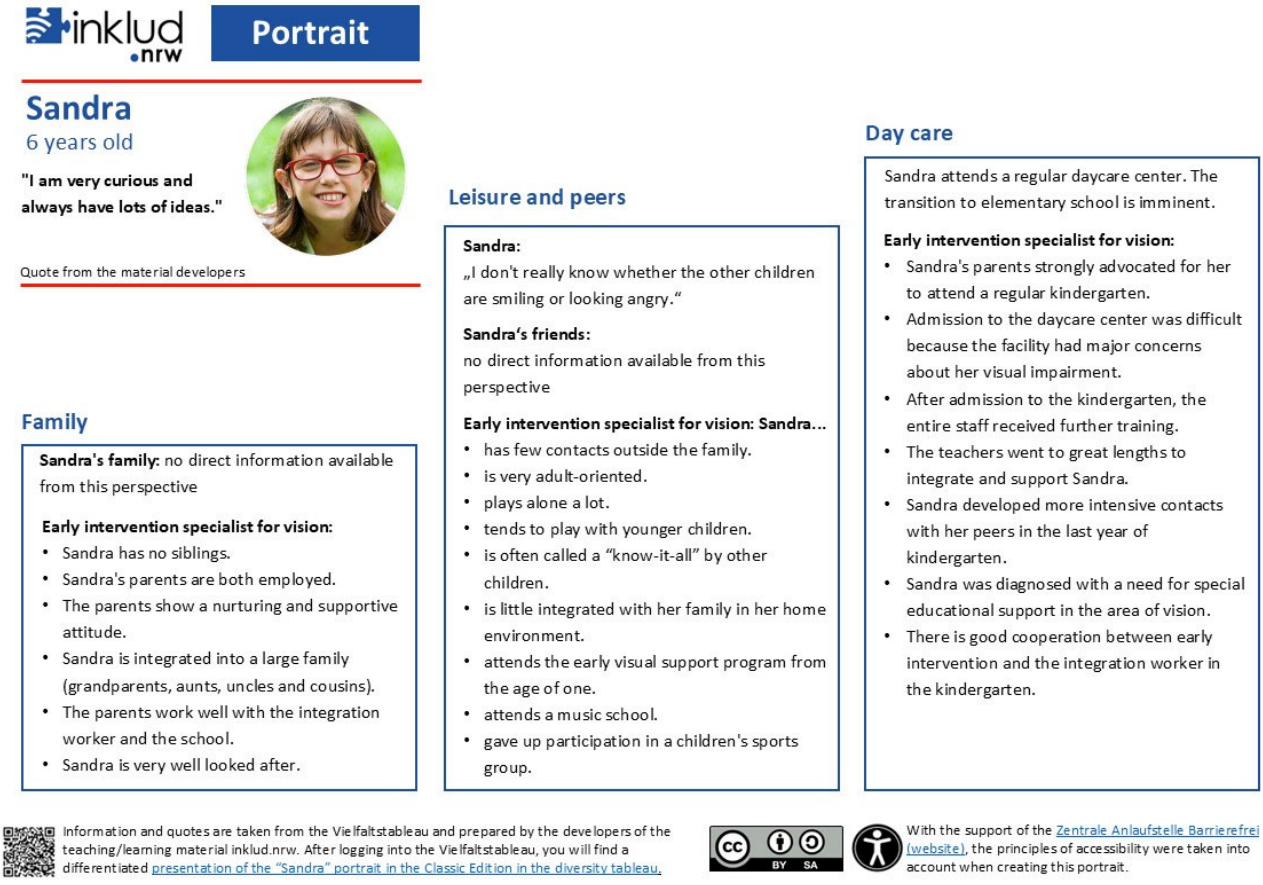

Figure 1: Exemplary portrait card of the *inklud.nrw* case study "Sandra"

4. Structure and Design of the Teaching/Learning Concept *inklud.nrw*

Following the theoretical principles described above, the aim of *inklud.nrw* was to design and develop a participation-oriented teaching/learning concept that theoretically and conceptually integrates inclusion, media education, and case study work. The OER-Content.nrw funding line mandates the creation of digital educational materials in the OER format. To ensure the quality of the freely accessible materials, the previously described theoretical principles have been incorporated into a separate didactic guideline that ensures the necessary coherence of the freely accessible teaching/learning concept, allowing even the smallest parts of the materials to speak for themselves and represent the theoretical claim as well as the conceptual core idea. The overall media infrastructure is based on the learning management system Moodle, which guarantees free accessibility across German universities. Thematically, the TLM are structured into various inclusion-oriented focal topics that connect to media education perspectives (cf. Figure 2, left column), centering on a case portrait (cf. Figure 1). Each child or adolescent is described in their individual starting position and social environment.

Subsequently, various task sets tailored to the case portraits are provided. Additionally, there is the option of a free portrait choice, which allows for the inclusion of a self-selected case example (cf. Figure 2, 2nd column from the left).

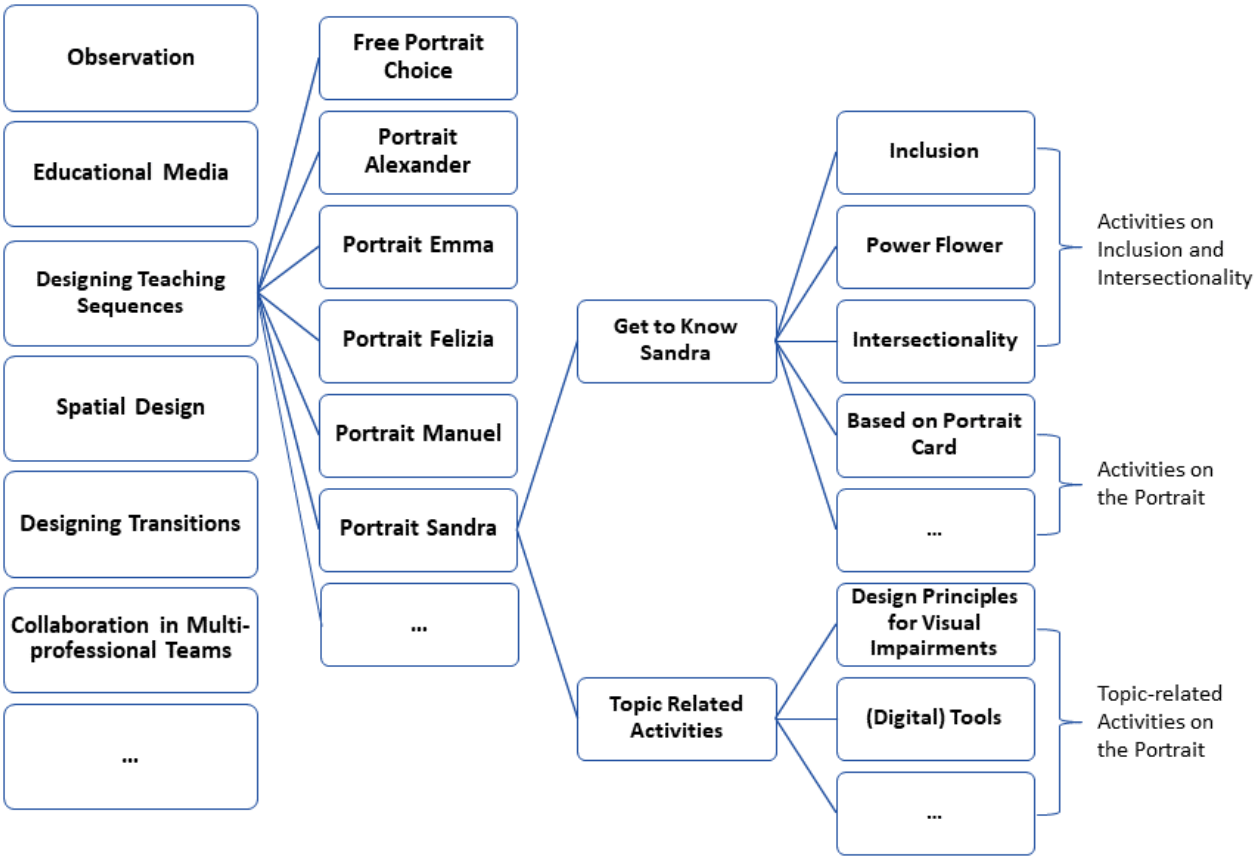

Figure 2: Structuring of the Moodle-based teaching/learning environment *inklud.nrw*

The step of selecting a focal topic was intentionally placed before that of choosing a portrait to counteract superficial and truncated case selection along categorizing lines of specific or limiting difference. The portraits are listed with an anonymized name, the age, and a meaningful quote from the child or adolescent. After selecting a topic and corresponding portrait, users can choose from various approaches to engagement (cf. Figure 2, right column, 2nd bracket), such as discussing or creating a portrait card or recording an internal monologue from the child or adolescent's perspective. In this way, the portrait design prepared by the case providers, TLM developers, and/or the students themselves becomes the subject of reflection, aiming to raise awareness and sensitivity regarding the impact of attributions when selecting and highlighting specific information, choice of words, or visual representations in the sense of reflective inclusion. This is followed by theme-specific tasks and activities that enable case-oriented engagement with the chosen focal topic (cf. Figure 2, bottom right).

The content focuses on individual, participation-oriented support that includes participation in, with, and through media, offering various questions and discussion opportunities for the individual child or adolescent regarding the focal topic. For example, students can utilize various media suggestions to write a glossary on three terms in the context of inclusion and/or intersectionality (e.g., heterogeneity, differences, exclusion). A following exchange through comments as well as discussion of the glossary entries in a seminar session can either help them answer questions regarding their understanding of the case

and their personal assessment of comprehensibility and technical correctness. Otherwise, it can enable a discussion of questions of scientific presentation (e.g., dealing with literature) and the differentiation of term explanations (e.g., appropriateness, scope, discipline specifics).

Engaging with the task descriptions and didactic notes makes clear which tasks build on each other and which can be combined freely, allowing educators to individually adapt the teaching/learning concept to the students based on prior knowledge and course context. In the spirit of the "*pedagogical double-decker*" and the potentials of intertwining inclusion- and digitalization-related content, the methods and the design of the teaching/learning concept itself are discussed by the users as well as by the material's developers. Accessibility, in terms of barrier-free design, has been achieved through typography, color, and format-specific principles. Engagement with design principles for accessible media thus not only occurs in the explicitly designated tasks but also makes the characteristics of these principles tangible within the teaching/learning concept itself (Otten, 2024).

5. Conclusion and Perspectives

The concept presented here for *inklud.nrw* offers an initial draft for the theory-driven development of a transferable, freely accessible teaching/learning concept that aims to synergistically and innovatively link the cross-sectional tasks of inclusion and digitalization through case study work in educational science and teacher education. The focus was on exploring how inclusion, media education, and case studies can be theoretically and conceptually based to develop a teaching/learning format for higher education that fosters high-level, subject-specific, and simultaneously (self-)reflective engagement in university students through new professional tasks. Participation, reflection, case study work, and the idea of the "*pedagogical double-decker*" provide the framework for this approach. The theoretical clarification and positioning carried out here proved to be extremely significant for both the academic and reflective quality of the material as well as for ensuring reflexivity within our team of developers (Stets & Vielstädte, 2022). Evaluation results from *inklud.nrw* also show that this concept can be regarded as successful: educators confirm that the material encourages a more in-depth discussion of inclusion (Kamin et al., 2022).

The question of quality assurance arises in a particularly unique way for teaching/learning concepts in the OER format (Ehlers, 2011), as freely accessible educational materials can be utilized, modified, and made available again for free use in a modular fashion (i.e., in situationally selected parts). This project has shown that a theoretical foundation must ensure the necessary *coherence* of TLM. This is likely to enhance the chances of professionalization-promoting engagement via the OER as well as preserving quality in the event of modifications and versioning by the users.

Four universities involved in the project used this concept in various course formats, and both educators and students evaluated it. Although they believed that the tasks' methodological design required some modifications, the results overall indicate the concept's viability for teacher education (Kamin et al., 2022). According to the educators and students, the intended goals of competency development have been achieved (Büker et al., 2022; Stets & Vielstädte, 2022). Nevertheless, findings of the follow-up project *InDigO* (Glawe et al., 2024) highlight the great potential of educators in universities sharing their teaching experiences and those in teacher education courses collaborating in the sense of Open Educational Practices (OEP). Interest in a common object—in this case, inclusion-oriented teacher training, with all its challenges and antinomies—evidently also provides opportunities and a "reason to persevere" for the new practices of cooperation and collaboration. Nevertheless, there exists a broad field of future research, particularly in terms of empirical validation

of the proposed teaching/learning concept, such as a more systematic comparison of perspectives from educators and students. Applying such research to teacher training in several countries might produce valuable findings. Finally, linking competencies for inclusion and digitalization in teacher education via case-based learning concepts will benefit from further international discussion and collaboration.

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The Intertwining of Inclusive and Digital Learning

A Scoping Review on Digital Learning in Inclusive Science Education

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Abstract:

This paper explores emerging trends in digitally supported inclusive science education, with a particular focus on inquiry-based learning. Drawing on UNESCO's (2001, 2017, 2020) definition of inclusive education and the Framework for Inclusive Science Education (Brauns & Abels, 2020), we conducted a review of the current state of knowledge on digital learning in inclusive science contexts. Our aim was to establish a foundation for future research on fostering inclusive inquiry-based learning through digital materials. While subsequent publications will address our research project more broadly, this paper presents the findings of an initial scoping review. We systematically analyzed the literature from the past decade to map and synthesize evidence on the use of digital learning tools in inclusive science education at the primary school level. Three key trends emerged: (a) research on digitally supported inclusive science education has predominantly focused on gifted students, rather than on those with special educational needs; (b) certain teacher training programs designed to integrate digital media into inclusive science education have shown promising results; and (c) teachers face significant challenges, particularly in their ability to engage all students with digital materials in inquiry-based science teaching. We discuss these findings in detail to provide starting points for future research on the role of digital tools in inclusive science education.

Keywords:

inclusive science education; digital learning; inquiry-based learning; self-efficacy; primary school

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1 Introduction

In the past decade, two key topics have gained significant prominence in educational research: inclusion and digitality. Although these areas are both critically important, they also present substantial challenges within education systems all over the globe that are striving to meet the diverse needs of learners. The concept of inclusive education has been interpreted in various ways across international discussions, with definitions shaped by cultural and educational differences (Ainscow, 2021; Makoelle, 2014; Shyman, 2015; Spandagou, 2021). Nel et al. (2011) emphasized the country-specific nature of inclusion, noting that sociocultural and educational contexts play significant roles in its implementation. Despite these variations, efforts have been made to develop a more universal definition of inclusive education (Makoelle, 2014). UNESCO's (2001) definition, aligned with the 1960 *Convention against Discrimination in Education* and *Sustainable Development Goal 4* (SDG 4) of the 2030 Agenda (UNESCO, 2017), centers on two key principles. First, every learner is equally valued, and none should be excluded based on factors such as gender, religion, language, nationality, ethnicity, social background, economic status, or ability (Ballard, 1997; NCERI, 1995). Second, inclusive education aims to identify and remove barriers—whether curricular, pedagogical, or related to teaching practices—and ensure equitable access to high-quality education for all learners.

The core principle of inclusive pedagogy—the removal of barriers—presents both opportunities and notable challenges. It holds the potential to transform schools into change agents (Howladar, 2018), fostering participation and well-being through quality education for all. However, empirical research has also identified significant barriers, such as inadequate teacher training, the perception of diversity as a challenge, physical barriers, underutilized resources, and a lack of effective organizational and pedagogical strategies (Arnaiz Sánchez et al., 2019).

A key issue in discussions about inclusive practices is the application of inclusive pedagogies across various school subjects. In science education, the *Framework for Inclusive Science Education* (Brauns & Abels, 2020) was developed to explore the relationship between inclusive pedagogy and science teaching. Based on a systematic literature review, the framework identified 16 categories, including *'Creating inclusive science learning environments,' 'Developing students' science conceptions inclusively,'* and *'Creating inclusive scientific documentation'* (Brauns & Abels, 2020, p. 22). However, these categories remain largely theoretical, failing to directly address how the specific characteristics of science education can be translated into inclusive practices (Wellington & Ireson, 2017). To bridge this gap, the framework introduced subsequent levels that focus on practical implementation, such as *'Enabling inquiry-based learning materially guided'* (Brauns & Abels, 2020, p. 22). In total, the framework includes 12 action-oriented subcategories defined by verbs such as *'supporting,' 'enabling,'* and *'creating'*. These subcategories provide concrete guidance for implementing inclusive science education through digital tools, action-based strategies, linguistic adjustments, and material support (e.g., Wellington & Ireson, 2017).

The second prominent focus of the past decade has been on digital learning, particularly in science education (Momani et al., 2023). In the context of inquiry-based learning, the *Eight Learning Events Model* by LeClercq and Poumay (2005) was one of the first theoretical frameworks to be used as a professional development tool, helping teachers integrate digital materials into their teaching (Nuninger et al., 2023). This model advocates for the standardization of core teaching and learning situations (Verpoorten et al., 2007), highlighting the phases of exploration, creation, experimentation, debate, and meta-reflection as essential for incorporating digital tools into inquiry-based learning (LeClercq & Poumay, 2005). Since then, various pedagogical frameworks for integrating digital media into science education have emerged (e.g., Bosse et al., 2019; Böttinger & Schulz,

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2021; Pannullo et al., 2025; Schaumburg, 2021). However, inclusion has remained a largely peripheral concern in these models. Whereas some frameworks mention inclusive practices—such as the importance of clear instructions and constructive feedback (Le-Clercq & Poumay, 2005)—they do not fully address the implications of these practices for inclusive teaching (Abels & Stinken-Rösner, 2022). With this review, we aimed to fill this gap by examining how the intersection of inclusive education and digital learning in science education has been explored in the literature and by identifying opportunities for further development in this area.

2 Research Question and Methodological Approach

Drawing upon the discourses outlined above, we examined empirical research at the intersection of digital learning, inclusion, and science education. Our primary aim was to identify emerging trends by systematically categorizing the existing research in these areas. Specifically, we explored the landscape of digital learning within inclusive science education to set the stage for future studies. To achieve this end, we conducted a scoping review of literature published from 2014 to mid-2024, thereby mapping and synthesizing the available evidence at the intersection of digital learning, inclusion, and science education. While the overarching research project, *Promotion of Inclusive Science Education Through the Use of Digital Materials* (PISE-DM), will be discussed in a subsequent article, we present the findings from the initial scoping review in the current paper[1].

By following Nightingale's (2009) and Snyder's (2019) literature review guidelines, our process adhered to the following five steps: (a) defining the objective, (b) developing a search strategy, (c) selecting studies on the basis of inclusion/exclusion criteria, (d) extracting data, and (e) summarizing findings and identifying gaps. To map the state of research on digital learning in inclusive science education, our inclusion/exclusion criteria (outlined in Table 1) ensured that only studies addressing both digital learning and inclusive science education would be included. Studies that focused solely on digital learning or inclusion in education, without a science education context, were excluded. Our criteria further specified that publications must be

Table 1: Inclusion criteria for our literature review

Inclusion criteria	Details
Type of study	• qualitative and/or quantitative empirical studies or • documentation of digital inclusive practices
Focus of the study	• digital learning • educational inclusion • context of science education
Type of participants	• practitioners working with students 4 to 16 years of age and/or • students 4 to 16 years of age from every background, gender, culture, nationality, religion, and geographical location
Type of intervention	• any kind (e.g., peer tutoring, one-on-one intervention, classroom-based intervention, short- and long-term intervention)
Publication type	• double-blind peer review • published from 2014 to mid-2024
Other	• studies must focus on both educational inclusion and digital learning in science education • studies focusing on either educational inclusion or digital learning are excluded

[1] For related work from the predecessor project TAPSE, see Andersen, 2020.

peer reviewed and published within the last ten years, ensuring both quality and relevance. The search focused on studies involving students between the ages of 4 and 16, as well as practitioners working with this age group. Given the varying structures of primary school systems across different countries (e.g., ages 6–10 in Germany, 4–12 in Luxembourg, 6–16 in Denmark), we considered a broad age range to capture relevant studies in primary science education.

Building on these inclusion criteria, we conducted a search using Google Scholar, Scopus, and Science Direct. In the first stage of the scoping review, we identified 91 papers focusing on the intersection of inclusive and digital learning. After applying the inclusion criteria (Table 1) and excluding studies unrelated to primary science education, we reduced the number of relevant articles to 28, which were retained for further analysis. Data were extracted from the selected papers and systematized using content analysis, as outlined by Bengtsson (2016). We developed a coding scheme around key themes such as digital tools, inclusive practices, participant demographics, and outcomes. Each study was reviewed, and relevant data were extracted accordingly. The data were then coded thematically to identify patterns and trends. To ensure reliability, three researchers independently reviewed the coded data, resolving discrepancies through discussion. Finally, the findings were synthesized to map trends in digital learning for inclusive science education and to identify gaps in the literature.

3 Findings: Emerging Trends in Digital Learning for Inclusive Science Education

The empirical research on inclusive education, digital learning, and science education is extensive and internationally widespread when considered separately (e.g., Ainscow, 2021; Howladar, 2018; Makoelle, 2014; Pedaste et al., 2015; Shyman, 2015; Sotiriou et al., 2020). Nonetheless, our scoping review revealed a significant gap in studies specifically addressing the intersection of these three domains: digitality, inclusion, and science education. Although some studies focused on two of these areas (e.g., Comarú et al., 2021), when all three were considered, digital learning was often treated as secondary or not central to the research questions or data collection. For example, although several studies have explored the intersection of inclusion and science education (e.g., Apanasionok et al., 2020; Librea-Carden et al., 2021; Sebti & Elder, 2024), the role of digital learning—such as testing a digital tool—was not a primary focus of the research in those studies.

The following presentation of our results highlights studies that addressed all three areas, though they often emphasized only two. Despite this limitation, our review identified three recurring themes that emerged as key trends in research on digital learning in inclusive science education.

1. Focus on gifted students over students with special educational needs

One key trend in research on digital learning in inclusive science education is the emphasis on supporting gifted students rather than on those with special educational needs (SEN). Several studies highlighted the benefits of digital learning materials for gifted students (Cerna et al., 2021; Ebenbeck, 2023), who often struggle in traditional educational settings, experiencing boredom that can negatively affect both their well-being and academic performance (Gottschalk & Weise, 2023; Rutigliano & Quarshie, 2021). Digital tools, such as interactive projects and digital books, engage gifted students by facilitating real-world connections and offering thought-provoking challenges (Gottschalk & Weise, 2023). Ebenbeck (2023) also underscores the effectiveness of Computerized Adaptive Testing (CAT), which adjusts the level of difficulty of questions in real time to match students' abilities.

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These digital tools have the potential to boost motivation and engagement, thereby allowing students more flexibility in pursuing individual interests (Rutigliano & Quarshie, 2021). Specifically, augmented reality and personalized online assessments have been shown to foster critical thinking and independent problem solving (Brussino, 2020; Chen et al., 2013). However, although research has explored digital learning tools for gifted students (e.g., Brussino, 2020; Rutigliano & Quarshie, 2021), there is a notable dearth of studies that have focused on the application of these tools to science education for students with SEN, as well as those from ethnic minority groups or indigenous communities and those who are asylum seekers or refugees. Particularly for asylum-seeking students, empirical studies remain scarce (Allen et al., 2021; Alper & Goggin, 2017; Dreamson et al., 2018; Idol, 2006; Sorbring et al., 2017), with a notable lack of research on how inclusive practices impact their educational experiences and how digital learning can support their participation in science education.

2. Promising teacher training programs for digital media in inclusive science education

Another trend identified in our review involves the growing recognition of the importance of teacher training for the effective integration of digital media into inclusive science education. There is broad consensus that science teachers need professional knowledge regarding both inclusion and digitalization (Kerres, 2018; Stinken-Rösner & Abels, 2021; Weidenhiller et al., 2022, 2024). However, teacher training programs aimed at integrating digital materials into inclusive science education differ substantially in content and methodology. Among these, the one-day in-service training by Weidenhiller et al. (2024) stands out for its effectiveness, as demonstrated by the pre- and post-survey results of 141 participating science teachers. This training addressed teachers' attitudes and self-efficacy regarding inclusion and digitalization. During the one-day session, teachers planned and implemented a digitally supported science experiment, receiving in-depth training on how to address the diverse needs of their students. The entire process —from planning to implementation and evaluation— was digitally supported (Weidenhiller et al., 2022), with teachers considering students' needs and potential barriers at each stage.

What distinguished this training from other professional development programs was its emphasis on empowering teachers to use digital media to design experiments and align each phase with the inquiry process. This approach encouraged teachers to adapt experiments to the unique diversity of their classrooms, tailoring strategies to meet students' individual needs. Pre- and post-survey results indicated significant improvements in teachers' attitudes towards digital media and self-efficacy across the TPACK domains (Weidenhiller et al., 2024). Notably, improvements were observed in the following three domains: pedagogical knowledge (PK), which focuses on students' individual needs; content knowledge (CK); and technological knowledge (TK), which includes the effective use of digital tools (Mishra & Koehler, 2006). Weidenhiller et al. (2024) emphasize that enhancing teachers' attitudes towards digital materials and boosting their self-efficacy are strong predictors of success in inclusive classrooms (Sharma & Jacobs, 2016).

This training program also stands out by focusing on the development of digitally supported experiments that address diverse student needs, in line with previous studies (Kerres, 2018; Stinken-Rösner & Abels, 2021) that have highlighted the importance of combining digital media design with inclusive teaching methods. Despite the promising results from such programs (for other studies with similar outcomes, see, e.g., Liu, 2013; Luo et al., 2023), our review revealed a significant gap in research on teacher training specifically designed to professionalize teachers in engaging all students in digitally supported inquiry-based science education.

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3. Challenges in using digital media for inquiry-based learning in inclusive science education

A third key trend identified in the literature is the recognition of barriers to using digital media in inclusive science education, particularly within inquiry-based learning. The complexity of the inquiry process was often found to present challenges, such as difficulties regarding materials and instructions (Stinken-Rösner & Abels, 2021) or methodological obstacles such as formulating hypotheses or reflecting on measurement inaccuracies (Baur, 2018). Research has highlighted several strategies for addressing these challenges and creating differentiated, student-centered learning experiences. One effective approach involves the strategic use of digital materials designed to enhance accessibility and reduce barriers through thoughtfully integrated multimedia design (Kerres, 2018).

A central component of inclusive inquiry-based learning with digital tools is the ability to adjust complexity, abstraction, and observation levels to meet the diverse needs of students, as demonstrated by Bruckermann et al. (2017). Other studies have explored how digital devices can support communication for students with physical impairments (Lidström & Hemmingsson, 2014) and have identified barriers to accessing digital tools, including physical, cognitive, and skill-related limitations (Sorbring et al., 2017). Additionally, studies indicate that certain digital tools remain inaccessible to students with SEN, particularly when essential features, such as text-to-speech software or subtitles, are missing or inadequate (Alper & Goggin, 2017). These findings underscore the importance of ensuring that digital tools are designed inclusively to cater to a wide range of learning needs in science education.

4 Discussing Research Gaps and Future Research Directions

Significant progress has already been made in inclusive science education, digital learning, and teacher training. However, our scoping review highlights a critical need for more focused research at the intersection of these three domains. Specifically, further studies are needed on the use of digital tools for students with SEN and on comprehensive teacher training programs that integrate inclusive education and digital learning. Overcoming barriers to digital inclusion in science education will require continued innovation, collaboration, and a deeper understanding of how to design accessible, differentiated learning environments for all students. Our findings revealed significant gaps in research on how the inclusion of all learners in digitally supported science education can be effectively facilitated. Although inclusion in science teaching and the digitalization of science education have been extensively studied individually (e.g., Ballard, 1997; Bruckermann et al., 2017; Comarú et al., 2021; Paul, 2018), few empirical studies have explored the intersection of these areas. This gap is particularly evident in primary science education, where the integration of inclusive practices and digital tools remains largely unexplored.

One reason for this gap may stem from the historical development of digital learning technologies in education. Digital learning was introduced later in primary schools than in secondary schools (cf. Kerres, 2018), resulting in a delayed start for both research and implementation. Additionally, challenges such as limited technological resources and insufficient teacher training have further hindered the integration of digital tools into primary science education. Moreover, the scarcity of studies on digital learning in inclusive science education may reflect broader trends in science education research. In the past decade, much of the focus has been on hands-on learning, which is perceived as more engaging for students and more effective for fostering a deeper understanding of scientific concepts (cf. Andersen, 2020). By contrast, digital learning has often been regarded as supplementary to hands-on learning in science education (cf. Lin et al., 2017; Pannullo et al., 2025). This emphasis on experiential learning

may have led researchers to overlook the potential of digital tools to enhance inclusion, particularly for students with SEN. Furthermore, the rapid pace of digital technology development may have outstripped teachers' ability to fully integrate these tools into inclusive teaching practices.

The evolving nature of inclusion itself is another important consideration. Whereas inclusion in education has traditionally focused on physical accessibility (Ballard, 1997), there is now a growing recognition of the importance of cognitive, emotional, and social inclusion (Ainscow, 2021; Brussino, 2020; Spandagou, 2021). When used effectively, digital tools have the potential to support all of these aspects by offering personalized learning experiences that cater to diverse learning styles and abilities. However, research has yet to fully explore how digital resources can be designed to unlock their full potential for inclusion in science education. The intersection of digitalization and inclusion presents a unique opportunity for interdisciplinary research. Combining insights from educational technology, disability studies, and pedagogy could lead to a more nuanced understanding of how digital tools can support diverse learners in science classrooms. Future studies could investigate the specific types of digital interventions that are most effective for different student populations, the role of professional development in integrating digital tools, and how digital learning can be scaled to ensure equitable access for all students.

Emerging trends from existing studies at the intersection of digitalization, inclusion, and science education reveal significant disparities in the focus of such research. Notably, there is more empirical research on certain student groups (e.g., gifted students) than others, such as asylum seekers and refugees. Given the growing number of refugees and asylum seekers worldwide (UNESCO, 2020) and the unique challenges these students face—such as discrimination, language barriers, and cultural differences (Cerna et al., 2021)—it is surprising that there is limited research on how to better include them by using digital learning materials. This gap is especially notable given the positive impact of digital learning on motivation and academic outcomes (cf. Lin et al., 2017) and underscores the need for research on how digital tools can be adapted to support the unique needs of refugees and asylum seekers to ensure their meaningful participation and success in science education.

Whereas some empirical research has explored how digital learning materials can promote the inclusion of students with SEN (cf. Alper & Goggin, 2017; Gottschalk & Weise, 2023), our review highlights the need for more studies on how these materials can help SEN students engage in inquiry-based learning in science. Future research should explore how digital tools can help SEN students understand natural phenomena, develop problem-solving skills, form hypotheses, and test theories. Investigating how digital materials can support students with specific needs (e.g., ADHD, autism, Tourette's syndrome) in inquiry-based science learning is also essential. Tools such as text-to-speech software, translation tools, and visual representations have already shown promise in supporting SEN students (cf. Gottschalk & Weise, 2023), making it crucial to explore how these tools can enhance SEN students' engagement in science education. More specifically, research should focus on how such tools can help SEN students design investigations, form explanations, and make real-world connections through exploration.

Finally, teacher training programs that focus on the use of digital media in inclusive science lessons warrant further attention. According to the in-service teacher training study by Weidenhiller et al. (2024), a promising approach involves having teachers plan and conduct digitally supported experiments while receiving training on how to address the diverse needs of their students. This approach not only enhances teachers' technological skills but also equips them to create an inclusive learning environment, enabling all students to benefit from digital media in science education.

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5 Conclusion

The integration of digital tools into inclusive science education presents both opportunities and challenges. Our scoping review underscores the need for further research into how these tools can best support diverse learners, including those with SEN, refugees, asylum seekers, and ethnic minorities. Although the existing evidence shows positive outcomes, further work is required to design tools that effectively facilitate inquiry-based learning and problem-solving for all students. Interdisciplinary research across educational technology, disability studies, and pedagogy is essential for advancing our understanding of how digital tools can foster inclusion in science education. Additionally, strengthening professional development programs for teachers is crucial for equipping them with the skills that are necessary to integrate these tools into diverse classrooms. By addressing research gaps and improving teacher training, we can unlock the full potential of digital tools to create an inclusive, empowering learning environment in science education for all students.

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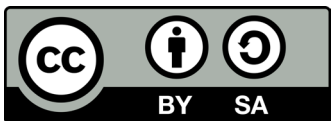

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Developing and Creating Inclusive and Interactive Digital Reading Environments with and for Students with ADHD

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Abstract:

Digital solutions are often claimed to have the potential to meet individual needs and make learning more accessible, thereby allowing schools to achieve more sustainable and inclusive learning for a diverse range of learners. However, digital tools bring both affordances and hindrances, which are intertwined with the students' prerequisites to learn and how the educational space and learning environment are set up. Following this, dilemmas occur as digital materials are assumed to level or reduce obstacles when they, in fact, also generate new obstacles and opportunities. To design and develop these tools with the potential of supporting qualitative learning opportunities for all students, knowledge of inclusivity and digital materials both need to be taken into account, two research fields that are seldom put together. This article contributes by reviewing hindrances to and opportunities for accessible learning in reading through digital materials and through the case of students with ADHD. The article introduces earlier research on the intersection of learning to read, digital materials, and students with ADHD. We thereafter suggest innovative design principles to uphold sustainable use of and learning through digital materials and elaborate on how these principles fit with ideas of inclusion and sustainable education. Consequently, the paper provides different stakeholders with the possibility to identify commonalities in working processes and to reach a joint language to discuss how digital educational tools should be designed and developed.

Keywords:

digital solutions; individual needs; sustainable and inclusive learning; collaboration; innovative design principles; reading abilities; ADHD

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1 The Promises and Pitfalls of Digital Learning

Digital solutions are often claimed to hold the potential to make learning in school more accessible, to achieve sustainable and inclusive teaching and learning, especially for students with disabilities (e.g., Alsalem, 2016; Ben-Yehudah et al., 2018). This potential relates well to international directives, such as the UN's Sustainability Goals (USG), which point towards inclusion as a strategy for their fulfilment (UNPD, 2015). Yet while there are incentives to work with inclusive teaching strategies and digital tools, both of these have repeatedly been shown to, besides creating access, at times hinder learning and contribute to new forms of inequalities and exclusion (Alsalem, 2016; Ben-Yehudah et al., 2018; Segers, 2017; Singer & Alexander, 2017; Wylie et al., 2018). In the case of Sweden, there is currently a societal debate and policy work ongoing, connecting the use of digital tools in school to the decrease in reading skills among students, which ultimately leads to a decrease in opportunities to participate in society (cf. SOU 2021:70; Prop. 2023/24:21). Contrary to this, research shows that the use of digital tools may lead to improved language learning and reading skills in certain student groups (e.g., Svensson et al., 2021), which in turn increases their opportunities to participate in society. Consequently, it can be concluded that, firstly, digital educational tools can create both hindrances and affordances for students who are learning to read. Secondly, this is an urgent topic that needs to be addressed by policymakers, developers of digital tools, researchers, and practitioners alike. Obstacles in the learning process can be caused by very different factors, such as lack of knowledge or cognitive, physical, psychological, or sociocultural prerequisites regarding the students or their environment. Therefore, sharing knowledge and responsibility between disciplines is important in the design and development of these digital learning tools.

Governments have invested in computers and other digital devices for their schools in various geographical and cultural national contexts, South Korea and Norway being two examples (Hatlevik et al., 2015; Lee et al., 2015). There are also non-profit initiatives such as One Laptop Per Child (OLPC), which provides sturdy equipment to children in distant and rural areas with socioeconomic disadvantages and poor internet access. These are global examples of policies and interventions aiming to provide inclusive, accessible, and high-quality teaching via digital tools. However, new disadvantages and forms of exclusion seem to occur when teaching is digitalized without proper preparation. Hence, the need to have insight into the specifics of the individual and organizational prerequisites becomes apparent: obstacles and opportunities differ between varying teaching contexts, disabilities, areas of learning, and the teaching tools at hand. In the case of students with ADHD and their reading, which will be our focus in this article, there are specificities regarding focus, concentration, and attention to take into account, especially when using digital media (Ben-Yehudah et al., 2018; Singer & Alexander, 2017). In sum, there are dilemmas in the fact that digital tools may both enhance inclusion and create new forms of exclusion, depending on how the design of these tools allows students to develop core reading skills. The inequities in how digital tools are developed and implemented in education reveal that not all students are afforded equal opportunities for accessible, inclusive, and equitable learning. Yet, these tools hold great promise and potential to support such outcomes if thoughtfully designed and applied. This situation calls for a response grounded in expertise, sensitivity to diverse needs, and collaboration across disciplines and stakeholder groups.

The purpose of this article is to contribute knowledge on how core design principles can be advocated in the development and adaptation of digital tools for learning how to read. More specifically, this is done with a focus on students with ADHD, a complex case in which stakeholders, knowledge, and collaboration

need to be interdisciplinary to promote and sustain learning. Three research questions have guided the study:

1) What is known in earlier research about the intersection of learning to read, digitality, inclusiveness, and sustainable learning in the case of students with ADHD?
2) What obstacles and opportunities are represented in the intersection of this earlier research?
3) How can design principles guide collaboration so that these obstacles and opportunities can be leveraged for the sustainable development and adaptation of digital learning tools meant for students with ADHD?

Consequently, both the overarching problem and the case of students with ADHD are explored from the perspective of what is necessary regarding the design and adaptation of digital tools. For this purpose, we will initially summarize earlier research on inclusive education for students with ADHD, digital tools, and learning how to read. To provide this foundation, we have discussed studies concerning the themes of *"digitalization and sustainable development," "digitalization and inclusion," "variations in ADHD and variations of school support,"* and *"reading in digital formats for students with ADHD."* The intersection of these themes is largely lacking, but highly needed to identify possible dilemmas in offering students with ADHD good opportunities to learn reading with digital tools. We thereafter provide *implications and design principles for sustainable collaboration* through a theoretical exploration of what design principles could respond to the intersections of challenges and opportunities identified in earlier research. We then also exemplify how these design principles might support the collaboration and shared responsibility that is key for sustainable digital learning practices, specifically for students with ADHD. Consequently, we discuss how a joint development process might include sustainable development for learning, inclusive education, and innovative working methods. This way, we aim to provide common ground for stakeholders in the design process, emphasizing core aspects of digital tools for reading acquisition, for students with ADHD and specific learning needs.

2 Digitalization and Sustainable Development

Sustainable development has been defined as the development of society that fulfils the needs of today without jeopardizing future generations' possibilities to fulfil their needs (Boström et al., 2020; The World Commission on Environment and Development, 1987). From a social sciences perspective, sustainable development entails three major areas: responsibility for equity, responsibility for the future, and collaboration and integration of institutions and knowledge (Boström et al., 2020). Creating equity in an educational setting is to provide all students with the same opportunity to learn. This means that for students to be able to learn, adjustments, resources, and teaching methods need to be provided based on these students' individual needs. Providing all of them with the same digital tools in the classroom could be called *equality*, but not necessarily *equity*. Providing all students with digital tools does not necessarily mean that they all have the same opportunity to learn (e.g., Jacquet, 2016). Personal digital devices in school seem to affect improvement in motivation and cognition differently and affect student groups differently: Motivational improvements are fast and seem connected to access to a personal digital device, whereas cognitive improvements have a slower ascent (Hylén, 2013). High-achieving students and students with special needs show faster cognitive gains than other student groups (Hylén, 2013). In line with and in addition to this research, Jang and colleagues (2016) conclude that digital textbooks are good means to increase learning motivation, but that changes to educational policies and teaching and learning practices are necessary to achieve cognitive and academic gains. Some students may need additional support,

either from the tool itself or from the teacher, to be able to use the tools (e.g., Jang et al., 2016). Consequently, in order to provide digital inclusive teaching, which is good for all students, several stakeholders need to collaborate and together consider how these tools can become flexible and supporting platforms to provide learning opportunities for all students. For example, students and teachers need to be involved in the process of developing and adapting tools, and developers need to collaborate with researchers and policymakers.

To promote equity, inclusion, and sustainability in education in the future, there is also a need to balance short-term benefits with long-term benefits (Boström et al., 2020). Providing all students with digital tools in education could be one way to achieve this, if done with care and consideration. Digital tools are claimed to be a part of modern education, they provide necessary learning opportunities and help students prepare for future educational and employment possibilities (Centeno Mediavilla et al., 2019). However, using these tools also creates unsustainable short-term obstacles that need to be solved. As mentioned, some students need additional guidance and instructions to use the tools if there is not enough support integrated into the tools themselves. Otherwise, they may miss opportunities to learn or even be disrupted in their learning. Not removing this short-term obstacle would mean that long-term benefits and further learning opportunities for the individual would be diminished (Jacquet, 2016), and thereby sustainable learning as well as sustainable development for learning would be impossible.

It has been pointed out that teachers need further education in handling digital tools and supporting their students to use digital tools for learning (e.g., Hatlevik et al., 2015; Lee et al., 2015) as well as more support from school leaders (Hylén, 2013; Hylén, 2017; Jacquet, 2016; Willermark, 2018). With early teacher support, students can gradually use the tools more independently. Although teacher and student training seem to solve the long-term need, this does not solve the unsustainable short-term situation. Instead, students and teachers are now seen as both the problem and the solution. It might seem a bit unfair to ask teachers and students to work harder to solve a problem that has to some extent been put onto them and to thereby take sole responsibility for producing public value (Peeters, 2013). This may risk increasing stress in students' and teachers' everyday lives and possibly increase long-term health risks instead of improving their long-term learning. It is important to realize that digital tools themselves have a great potential to support their users, both students and teachers, in how to use them. Developers should therefore include functions and manuals as user support in digital educational tools which can help prevent everyday stress for both teachers and students. This is a way to share responsibility for making learning sustainable and further sustainable development for learning.

From the examples above it becomes clear that there are many stakeholders involved in the use of digital tools in education, such as students, teachers, school leaders, developers, and researchers. Their unique perspectives, as well as the shared experiences between them, constitute a wealth of knowledge. We claim that the responsibility for digital tools in education must be shared by all stakeholders to address the third area of sustainability: interdisciplinary and transdisciplinary collaboration. This also includes bringing the students onboard in the process of designing, developing, and adapting digital tools, as they are core stakeholders. This approach connects responsibility with equity and the ethical aspects of education. We draw on Boström and colleagues (2020), who point out that there is a recurring interest in solving these complex issues both by interdisciplinary collaboration within science, and transdisciplinary collaboration between science, practice, and other sources of knowledge. Taking shared responsibility for education concerning digital tools, interdisciplinary collaboration would imply that researchers in pedagogy and engineering need to

engage in joint developing of programs. In addition, transdisciplinary collaboration would imply that the knowledge of prospective users, such as students, teachers, and school leaders, should be involved as partners when developing such tools.

3 Digitalization and Inclusion

Digital literacy has become crucial to finding a job and taking part in society (Centeno Mediavilla et al., 2019). According to the European Commission DIGCOMP project (2019), to be digitally literate means to be able to "articulate information needs, to locate and retrieve digital data, information, and content. To judge the relevance of the source and its content. To store, manage, and organize digital data, information, and content". Other key components of digital competence identified in the report are communication and collaboration, digital content creation, safety, and problem-solving. To broaden educational practices to engage and support all students, digital literacy can be a cornerstone in planning for inclusive education, allowing for a wider range of educational practices. Inclusive education, however, has been described in various ways and varies when put into practice. In its perhaps most simple definition, it means creating learning environments in which it becomes possible to *involve all* students (Nilholm, 2020). This includes both academic and social participation, as well as (spatial) access for every student (e.g., Göransson & Nilholm, 2014). For students, inclusion can be translated into experiencing trust, a community, and a sense of belonging, all of which may improve their motivation and self-confidence (Allan & Persson, 2020).

Digital literacy can enhance students' learning and participation in school. Working with digital textbooks may create (more) equal educational chances by allowing users to change settings—e.g., by changing the size of the text, translating words, and additional or optional illustrations—in order to better suit students' individual preferences and needs. Alsalem (2016) argues that, compared to traditional printed media, digital technology has had a far greater impact on literacy, enabling a larger population to see digital literacy as a truly communicative and social endeavor rather than communicative for the few and passive information gathering for the many. In a survey, teachers' responses to digital literacy focused on digital tools helping to overcome difficulties in students' learning, specifically for students with disabilities. Digital educational tools were described by the teachers as a way to create engagement and motivation, to be flexible, to be able to multiply representation, and even as a medium for enhancing students' skills and achievements (Alsalem, 2016). Students may express their understanding in different digital forms, be it by writing a report, developing a podcast, or building an interactive presentation. In other words, digital technology allows for a wider variety of educational practices and provides more platforms that may motivate, engage, and overall improve all students' learning experience (Alsalem, 2016; Kraft, 2023; Nilsson, 2021).

When re-thinking the intersection of digital tools and inclusive education, it is important to revisit the policy, practice, and intentions of inclusive education. Key recommendations for inclusive education made by the European Agency for Development in Special Needs Education (2009) include the following: Widening participation for all learners, education and training in inclusive education for *all* teachers, organizational culture that promotes inclusion, support structures organized to promote inclusion, and flexible resourcing systems that promote inclusion. To help foster cultures of inclusivity and promote teachers' work to give voice to students' perspectives and the need for digital tools, Gillett-Swan and Sargeant (2018) drew up principles for a Voice Inclusive Practice (VIP). In their article, they depart from participation principles from the United Nations' Convention on the Rights of the Child and Shiers's pathway to participation. VIP aims to give students a voice in their education that is not only authentic, but also achievable in practice. Gillett-Swan and Sargeant (2018) have built further

on VIP, creating VIP Digital. The authors mean by VIP Digital that digital educational tools need to be accessible to all, and that educators and students should share decisions on which tools to use. The final point of VIP Digital is that there should be reciprocal knowledge and skill transmission between students and teachers regarding the use of digital tools.

Reciprocal knowledge and skill transmission are important for school leaders to facilitate and give a tangible starting point for teachers when planning and conducting inclusive education with digital educational tools. To make progress, collaboration is needed as there are both challenges and opportunities for students and teachers alike. As mentioned above, there is a lack of digital education and supplementary training for teachers. Indeed, 18% of lower secondary school teachers in the OECD (2020) international survey report a strong need for more training in digital tools. However, not all teachers are reluctant to use digital educational tools. 43% felt well prepared using information and communication technologies (ICT) when starting their profession, 56% have already participated in training on using ICT in the classroom, and 53% actively use ICT in the classroom. Overall, the use of ICT in teaching has increased by around 15% in only five years (between the dataset of 2013 and 2018; OECD, 2020).

Considering these data together, there is a positive trend to be seen regarding the need for ICT and using or training to use ICT. In addition, teachers are educated in several methods of educational practice and can help see and voice students' needs, some of which the students themselves may not even be fully aware of yet. Furthermore, while students are often described as tech-savvy and unafraid (e.g., Gillett-Swan & Sargeant, 2018), not all of them find digital tools easy to operate. While some overestimate their own digital literacy (Ben-Yehudah et al., 2018; Singer & Alexander, 2017), others, often from low-income families, don't see the need to use digital tools (Jacquet, 2016). Therefore, the point of reciprocal knowledge and skill transmission between students and teachers is important as a good example of why integrating the knowledge of stakeholders from different status groups, as discussed above, may contribute to the creation of a shared responsibility for inclusive education. Unfortunately, the VIP Digital principles leave out how to include developers of educational digital tools, although a close collaboration would certainly make for user-friendly products, especially when stakeholders have different views on the teacher, assessment, and learning in schools (Ideland, 2020). As a matter of fact, the collaboration between several professions in digitalizing school development projects has already proven fruitful for students' learning (Karlsson, 2023).

The question is how to conduct such a collaboration. The four design principles of innovation (British Design Council, 2019) may be helpful as a guide, especially when used alongside the VIP Digital principles. The four design principles include—among other principles—understanding the users' needs and promoting communication and collaborative efforts (British Design Council, 2019). These principles will be described in depth in the discussion part of this article as they fit with the idea of inclusion through special education. Inclusive education stresses the importance of including *all* students and *all* teachers to meet everyone's needs (e.g., European Agency for Development in Special Needs Education, 2009; Nilholm, 2020). Reciprocal knowledge transmission and collaboration are needed for developing the needs-driven digital tools (Gillett-Swan & Sargeant, 2018) necessary to create these teaching and learning environments.

4 Variations in ADHD and Variations in School Support

As a part of facilitating reciprocal knowledge and skill transmission, and understanding users' needs, this article aims to provide stakeholders with a common ground regarding reading with digital tools

for students with specific needs. The case of ADHD helps to understand the complexity of student groups and the educational context they are in. This complexity calls for a level of flexibility in digital tools that can be developed by involving actual users in evaluating these tools. Common ground may facilitate joint development processes that can include sustainable development for learning, inclusive education, and innovative working methods.

Schoolchildren with Attention Deficit/Hyperactivity Disorder (ADHD) can have problems with maintaining attention and effort, as well as with organizing and finishing tasks. This may result in poor academic achievements and, among other issues, difficulties with reading development (DuPaul & Stoner, 2003; Tannock, 2007). Teachers, however, often perceive a diagnosis as too vague as a tool or information to gain knowledge on what adaptations the individual needs (Ågebrant, 2016). The heterogeneity of this student population is a likely reason for this observation. An ADHD diagnosis includes attention difficulties and overactivity, both of which may be present to different degrees and vary with environment, age, and gender (Socialstyrelsen, 2016). Furthermore, reading comprehension depends on several factors such as the individual reader's knowledge and use of strategies, text genre, task design (Snow & RAND 2002), and even the design of a digital environment (Segers, 2017; Wylie et al., 2018). Hence, many factors weigh in on how well students with ADHD receive digital reading education and support for their learning. Below, we briefly review a few factors that highlight the complexity of the diagnosis and its relation to academic reading achievements.

Students with ADHD can have problems with maintaining attention and effort, as well as organizing and finishing tasks, i.e., *self-regulation* (e.g. Reid et al., 2005). Self-regulation is a part of higher-order cognitive functions and is dependent on executive functions (Blair & Ursache, 2011; Rueda, Posner, & Rothbart, 2005; Schilhab, 2017). Executive functions, such as sustaining attention, help students focus on relevant information. Because of this, executive functions are closely linked to academic achievements (Chan et al., 2008; Diamond, 2013). However, attention difficulties take different forms in students with ADHD. In a study conducted by Tsal et al. (2005), eight-year-olds with ADHD predominantly showed difficulties with sustained attention, which could be clustered into three categories: difficulties with (1) *selective attention*, (2) *executive attention*, and (3) *orienting of attention*.

Furthermore, in a review of 72 studies investigating academic achievements in persons with ADHD, 69 showed that persons with ADHD displayed lower performance in reading, writing, and math, but in three studies persons with ADHD showed higher performance than the controls (Frazier et al., 2007). No significant gender differences were found for academic achievements (Frazier et al., 2007). Although there may not be any noticeable gender differences in academic achievements, research in special education has shown that not all students with ADHD receive the support they are entitled to. This support rather depends on educators' views on the diagnosis (Hjörne & Evaldsson, 2015). For example, boys are often diagnosed earlier than girls because of acting-out behaviors (Kopp et al., 2010), whereas teenage girls with ADHD report having more depression-related problems than their male peers (Rucklidge & Tannock, 2001). This may suggest that the source for problems with academic achievements is partially different for girls and boys if educators and schools do not recognize what type of support they need, and when.

4.1 Reading in Digital Formats for Students with ADHD

To understand a text, both on a surface level and in depth, implies that the reader engages in various reading strategies while reading, such as monitoring their own comprehension of the text. Comprehension monitoring is a crucial strategy as it allows the reader to decide on and self-regulate other reading strategies

(Duke & Pearson, 2002), e.g., looking up the meaning of a word or skipping back in the text to search for an important reference. When using digital reading tools, the academic outcome is related to students' use of self-regulating strategies (Winters et al., 2008). For example, when asking students about their self-regulating strategies and digital literacy in questionnaires, self-regulation proved to be mediating the effect of digital literacy on the students' grades (Lee et al., 2015).

Sustainable development in learning for students with ADHD can be achieved by working inclusively and making reading accessible. Research shows that reading can be made accessible for these students by using a digital medium that helps maintain their attention for the task, but there are certain prerequisites needed (Ben-Yehudah et al., 2018). These prerequisites involve supporting focus and working to counteract inattention, hyperactivity, and impulsivity, for example via literacy programs that adopt augmented reality AG (Tosto et al., 2021). These findings are in line with research on digital reading in adults with ADHD, as metacognitive scaffolding supports concentration and focus, leading to opportunities to reach the same level of competence and comprehension as the group of students without ADHD (Brann & Sidi, 2025). In general, Ben Yehudah et al. (2018) show that reading in a digital environment may enhance engagement and time spent on tasks for young students with ADHD. Their study also shows that multimedia content may support comprehension by enhancing engagement. However, if the material proved too long, these potential benefits of multimedia learning were also lost for students with ADHD. Other studies show that when reading is AI-assisted and auditory, and used to support learning content rather than learning to read, it can be beneficial for students with ADHD. The increased motivation to learn the content helps engage students in the reading process (Jafarian & Kramer, 2025).

To further understand the case of students with ADHD and each student's needs in learning how to read, it must be considered that reading comprehension varies with age and digital environment. Linear texts in a digital medium, such as an e-reader, may prove helpful to elementary school students with ADHD: more correct answers are given and students spend more time on task compared to analog text. For high school students with ADHD, however, linear digital texts only help if the students can double the line spacing (Ben-Yehudah et al., 2018). In addition, high school students may seem confident regarding their digital reading skills, and their digital reading speed may also be faster compared to printed text, but they still appear to be at a slight disadvantage in comparison to students without ADHD (Ben-Yehudah & Brann, 2019). However, similar patterns or results are shown in studies that focus exclusively on typically developing high school students. They, too, are confident that they do better with digital texts and prefer these, but their performance tends to be better when they work with printed text (Singer & Alexander, 2017).

Together, earlier research indicates that academic gains cannot be expected to show just by using a changeable reading format. Motivation and reading speed seem to be enhanced by a digital format, as well as the students' confidence in their reading skills. Yet, while enhanced reading speed, reading fluency, and confidence are all important for reading development and understanding digital texts, they do not guarantee long-term learning. Reading fluency may predict immediate recall of web-based text, but vocabulary knowledge and reading comprehension in printed text may also predict comprehension and long-term learning in web-based text (Boechler et al., 2006). Hence, it is the processes that enhance concept knowledge in digital reading and help students understand the connection between previous knowledge and new knowledge that can support in-depth comprehension and long-term learning.

Similar to Jang et al. (2016), Ben-Yehudah et al. (2018) conclude that teaching practices, such as the role of teachers as effective mediators of digital training,

should be examined to ensure that students benefit from digital reading tools. Consistent with these reviews, Schilhab (2017) argues that it is not possible to overcome challenges by just using and getting used to digital tools, but that there is also a great need to practice, and therefore teach, self-regulation when using such tools. For example, the hold that digital tools take on readers' attention has two sides. On the one hand, reading on a digital device can generally keep readers' attention in a way that helps them stay on task and complete the reading that is required in a teaching/learning situation (Schilhab, 2017). On the other hand, the mere knowledge that the same device also offers other activities, such as checking emails or social media, may divert attention from reading comprehension processes (Przybyliski & Weinstein, 2013). So, to stay on task and finish reading, readers need to actively monitor their understanding of the text and make use of reading strategies. Since students with ADHD benefit from self-regulation interventions (Edwards et al., 1995; Johnson et al., 2011; Reid et al., 2005), digital reading tools can be designed to help them learn to apply various reading strategies to understand the text (Askell-Williams et al., 2012; Devolder et al., 2012; McClanahan et al., 2012).

To summarize, great complexity is revealed by students with ADHD and their reading practices in digital environments. The individuals in the student group, and therefore also their needs, vary. Consequently, schools find it difficult to provide appropriate individual support. Students' reading gains also vary by age and digital learning environment. For example, students who read faster when reading in digital mediums do not necessarily improve their reading comprehension (Ben-Yehudah & Brann, 2019; Singer & Alexander 2017). Hence, they still need more thorough help checking what they understood from the text, not only how far they came reading it. Here, digital tools that support the learning-to-read process and using reading strategies could be of help, as shown by research. Importantly, the support structures that work for these students—namely audio-support or simplistic texts in terms of content—are not necessarily the ones traditionally included for supporting reading development in digital tools. What is also needed in the case of ADHD, is mental scaffolding and metacognitive support that can be provided by adding a flexible and digital guide to the reading process. Teachers, schools, and software developers need to collaborate to prioritize ADHD students' needs and facilitate opportunities for deep reading comprehension in digital texts.

5 Implications and Design Principles for Sustainable Collaboration

We started by stating that while digital solutions have the potential to meet individual needs and make learning more accessible and sustainable, they might also generate new forms of exclusion. Herein lies a dilemma. Consequently, to better understand the potential of digital tools in education, we have reviewed research on reading comprehension in digital formats for students with ADHD. In summary, results show that reading in a digital environment seems to enhance some aspects of reading for these students, namely focusing and supporting attention, higher motivation and faster reading speed (e.g., Jang et al., 2016; Hylén, 2013). Although these aspects are important for learning from text, they do not seem to lead fully to deep comprehension, long-term learning, and higher academic achievements. Similarly, students with ADHD are more engaged by digital reading tools and show higher reading speed than when reading printed texts (Ben Yehudah et al., 2018). As they progress towards high school age, they also grow more confident regarding their use of digital tools, but there do not seem to be any benefits to deep comprehension on a general scale. This is, in addition, highly contextual and depends on what features digital tools offer. Audio support only is not enough, whilst artificial intelligence (AI) and AG seem to be fruitful, but research is not yet conclusive. Also, even though digital literacy

can enable participation for all students (Alsalem, 2019), this does not mean that all students are capable of successfully self-regulating their own learning processes. Students therefore need the guidance of the teacher's pedagogical insights, and although they often are digital natives, reciprocal knowledge transmission and collaboration are needed when working with digital tools (Gillett-Swan & Sargeant, 2018). Consequently, there are pitfalls and obstacles as well as opportunities to support reading skill acquisition with digital tools in the case of students with ADHD. We conclude that digital tools do not automatically enhance the sustainable development of learning and inclusive education simply because they are digital and allow for more flexibility. Students still need guidance to regulate their use of reading strategies while reading in a digital environment.

Throughout this text, we have pointed out that shared responsibility for the development and use of digital tools in schools is necessary for sustainable development and inclusion in education. Because digital tools create new opportunities as well as obstacles, researchers have called for more student and teacher training. This, however, comes with the risk of seeing teachers and students as both a problem and a solution to the question of sustainable digital education. In the literature on sustainable education (Boström et al., 2020) and inclusive education (Gillett-Swan & Sargeant, 2018) both collaboration and knowledge transmission between several professions and stakeholders are discussed as possible ways of sharing this responsibility. To share responsibility for sustainable and inclusive digital learning environments, a collaboration between students, teachers, schools, scientists, and developers is necessary. However, both research (Ideland, 2020) and media (Bergling & Hedman, 2021) report that, for example, school practitioners and developers of educational technology have different ideas of what works. Such differences might stem from poor communication and knowledge exchange.

For improved communication and knowledge exchange between stakeholders, and ultimately sustainable development of schools and inclusive education, we will display a model of collaboration principles and work process in the following. The *four design principles of innovation* are then put in relation to prerequisites for *sustainable and inclusive education*, as identified in earlier research. The four design principles of innovation are used by innovators in various fields (British Design Council, 2019). The first design principle states that when designing, one ought to be putting people first. This means that an understanding of the needs, strengths, and aspirations of those who will be using digital tools should guide the design process so that the outcome meets actual needs. The second design principle is to communicate inclusively and use multimodal ways to help people gain a shared understanding of problems and ideas. This implies that effort needs to be made so that communication between stakeholders (students, teachers, developers, researchers, and policymakers) works. This could, for example, be achieved through joint webinars or workshops during which multimodality is advocated to reinforce inclusive communication to increase possibilities for shared understanding. The third design principle advises a collaborative spirit and for stakeholders to get inspired by one another. To co-create, it is necessary to take on board each other's ideas. The fourth and final design principle points towards the need for collaborative processes to entail many small iterations and to do this in four phases. This allows the collaborating stakeholders to uncover potential errors and risks early and to build trust with regard to common goals being kept in sight.

The three first principles mirror values that are also held within the field of inclusive education, which stresses the importance of including all students and all teachers to meet everyone's needs (e.g., European Agency for Development in Special Needs Education, 2009; Nilholm, 2020). The last design principle of innovation provides an idea of how to make this collaborative process sustainable through an iterative

process that has four phases: *Discover needs, Define solutions, Develop, Deliver*. In this case, designing and developing the use of digital tools for learning how to read means to create concepts (and prototypes) that need to be tried out and modified iteratively because of the many reading strategies involved. The first phase in achieving this is implementing the principles to ensure that the collaborators can discover and identify a variety of needs together. If, as in the case of this article, the aim is to create a digital tool to support students with ADHD in learning how to read, there is a need to identify this student group's diverse needs. In the second phase, collaborators need to define and choose a few solutions and designs to work with. In the third phase, these need to be developed and after iterations of testing and revision, in a fourth and final phase, the designers and developers can deliver digital solutions that, in an ideal world, now work inclusively and provide sustainable learning paths for all students.

After delivering a functional tool, however, the process needs to begin anew as the service needs to be evaluated by discovering new needs and solutions, again defining, developing, and delivering them. By allowing small iterations and introducing interim goals to the process, all stakeholders can test together what kind of flexibility a digital tool needs to have and what kind of support structures it needs to offer such a diverse population as students in schools. Although teachers' resources and instructional time are rarely sufficient for development work or for addressing all parts of the curriculum equally, iterative and participatory curriculum design has shown positive outcomes for both students and teachers (John et al., 2018). The iterative processes described in the *innovative design principles* can therefore be seen as both inclusive and sustainable ways to work in education and support the reciprocal transmission of knowledge and skills that is called for in both sustainable development and inclusive education (Boström et al., 2020; Gillett-Swan & Sargeant, 2018). We hope that the contribution of this paper is giving several stakeholders the possibility to reach a joint language and strategies in developing digital tools, to discuss how digital educational tools should be designed and developed. When realizing that one stakeholder cannot work without the other, synergy can be created and inclusion in the learning process, sustainable learning, and simultaneous sustainable development of digital tools can be realized.

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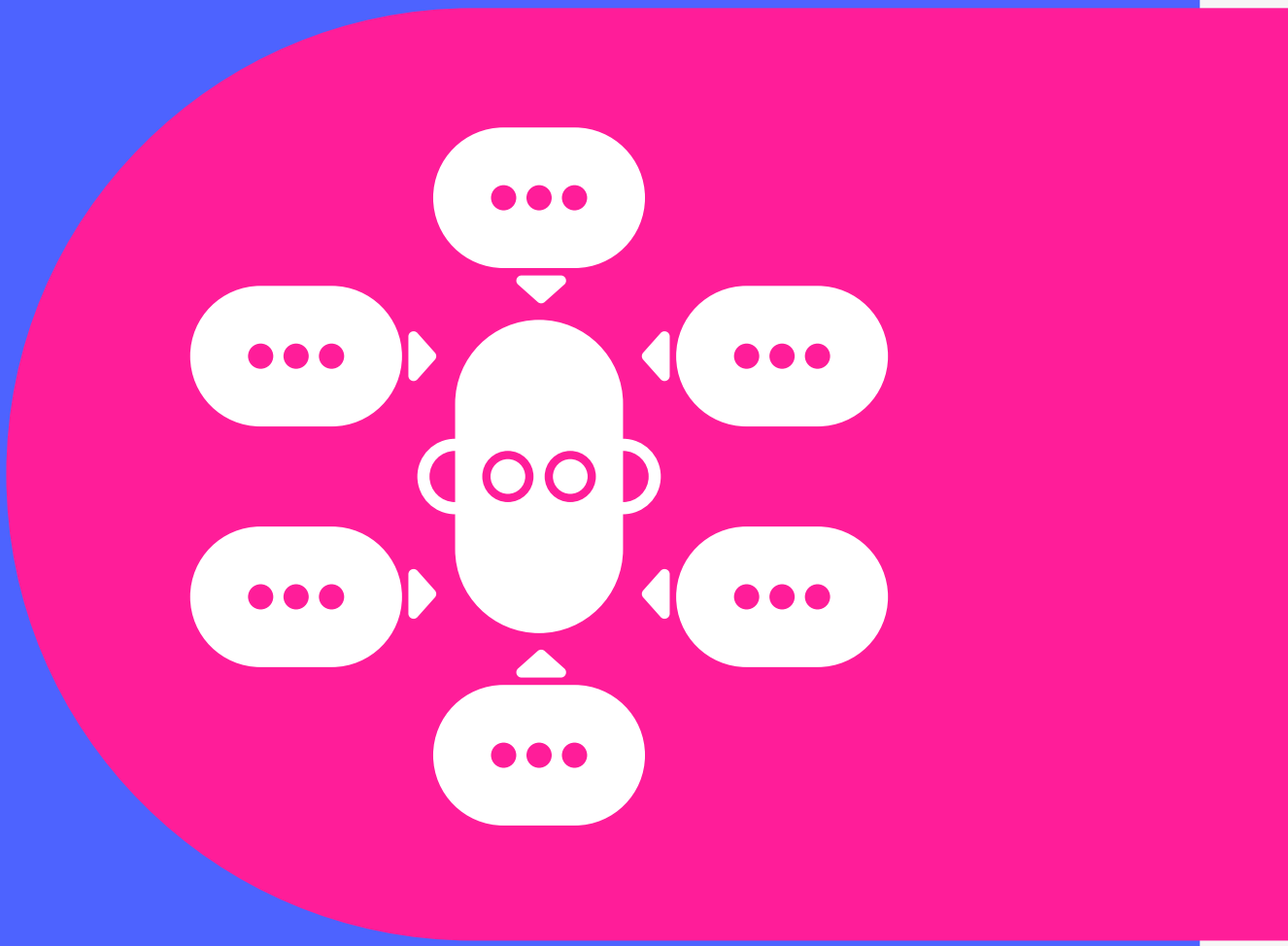

Section II:
Meta-Reviews

FRoLLM - Framework for the Reflection of Living Learning Materials.

Teaching and learning materials — e.g. textbooks, worksheets, learning apps, educational videos etc. — are an important core element of your everyday teaching and learning experiences. However, we rarely discuss the materials critically. The Framework for the Reflection on Living Learning Materials helps you think more deeply about the teaching and learning material you use on a daily basis. It was designed within the **digiLLM project** to support the inclusion-sensitivity of educational materials, taking into consideration various learners' needs.

There are six "areas" guiding your reflections.

- Learners' needs
- Learners' environment(s)
- Learning feedback for learners
- Learners' reflections on learning
- Learners' agency
- Philosophy

digi–LLM

visit the digiLLM website to learn more about FRoLLM and the digiLLM project!

Learners' needs

Area	Introduction	Reflection Questions	Indicators
Learners' needs	The material should be **sensitive to various learners' needs** (different learning levels, interests, backgrounds, potentials and limitations). Hence, **it should offer various ways of how learners can learn** about the same subject matter on different levels of complexity. The material should rely on **different kinds of medial representation** and should be adaptable to certain needs of the individual (accessibility, cultural representation). The material **should help the learner to actively shape their learning paths themselves**, enabled by providing choices between different options on how to work/ proceed with the learning material.	Does the material offer **various learning paths/ tasks** for the same subject matter in a **differing complexity level?**	According to the learner's needs, the material allows learners to work on different learning levels. For example, • *it provides a framing of the content (e.g. statics in bridge building) and* • *an overarching question (e.g. how can you stabilize your bridge so that it can carry cars?)* Even though all learners work on the same question, the level of complexity on how to approach the question can be chosen by the learners themselves. For example, • *a learner can build a bridge with prefabricated components while another constructs a bridge without pre-given information. A third learner might use "info cards" that provide information about static elements such as the stable triangle.*
		Does the learning material offer different levels of **scaffolding (support for learning)** according to the degree of learners' learning difficulties?	The material offers scaffolding to problem-solving. For example: • *by indicating the sequential steps of the solution,* • *showing what to start with* • *giving hints* • *modelling* • *asking guiding questions* When a task requires writing an essay, graded scaffolding can be offered, for example • *by providing an outline/structure* • *by providing guiding questions for each paragraph* • *by providing a model text to imitate*
		Are there **different kinds of representation** of the subject matter adapted to various learners' needs (UDL, Inclusive Design Guide)?	Key concepts presented in one form of representation (e.g., a text or a math equation) are supplemented with an alternative form of representation. For example: • an illustration • diagram • table • model • video • comic strip • animation Alternatives for visual or auditory information are available. For example: • descriptions are provided for images and videos • graphic symbols are provided with text descriptions

Area	Introduction	Reflection Questions	Indicators
Learners' needs		Can the material be **adapted to individual needs** by changing it partially (OER)?	The material can be customized so it is possible to make adaptations and changes. For example: • *size of text and images* • *the colour used for emphasis* • *the volume or rate of sound* • *the speed or timing of video etc.* In addition, adaptations to the learners, their learning environment and local, temporal and political contexts are also possible/easily to implement.

Learners' environment(s)

Area	Introduction	Reflection Questions	Indicators
Learners' environment	Based on a broad understanding of environment, the material should be **adaptable for various kinds of learning scenarios**, might they take place in groups or individually. A material should be adaptable to different physical surroundings (at home/ in the classroom/ library/ hospital), but also digital environments (e.g. during distance learning scenarios). Hence, the material should not have any particular demands, which may limit the usage to a specific location or setting. This implies the inclusion-sensitivity of digital materials in terms of **accessibility and openness**.	Can the material be used in different kinds of **group work as well as for individual work**?	The material can be used by one learner but also provides impulses so that two or more learners can work on the same task together. This makes it necessary to provide, for example, additional selected stimuli to the material in order to encourage discussion with the partner(s). For example: • *Comparing the partners' ideas on action on climate change in a shared online mind map.*
		Can the material be used in **different physical and digital learning settings**?	The material can be used in the classroom as well as at home, in the library or in hospital etc. Also, it is usable in different digital learning scenarios. This requires that tasks are based on easily accessible components. For example: • *the material may also be accessible with a poorer internet connection* • *there are alternatives for audio content if headphones are not available or the environment is noisy* • *it consists of easily accessible components, e.g. a task in science education might be to build a bridge out of paper in order to learn about statics*
		Is the material **available and freely accessible in different formats**?	The material is available on the PC or tablet as well as in a mobile phone version. This implies that the material requires formatting that makes images, text modules and interactive elements easy to display on different technical devices. The material is available in different formats and publishedunder an open license, allowing for people to freely use, adapt, remix and share it.

Learning feedback for learners

Area	Introduction	Reflection Questions	Indicators
Learning feedback for learners	The material should imply elements of **qualitative as well as quantitative feedback**. It should enable self-assessment formats as well as peer- feedback. Feedback can be designed as immediate learning feedback or as a more broad reflection on the learners' progress. The provided feedback elements **should support the learners in reflecting on their learning process** in a valuing and affirmative way. Additionally, feedback options may appoint to next steps in a learning journey.	Does the material imply **different kinds/formats of feedback?**	The material includes checklists or rubrics that guide learners to evaluate their own work or the work of others and provide criteria for improvement. For example, • *a checklist for writing a persuasive essay might include items such as "I have a clear thesis statement", "I have provided relevant evidence to support my arguments", "I have addressed possible counterarguments and refuted them", and so on* • *a rubric might assign different levels of performance (such as excellent, good, satisfactory, or needs improvement) to each item, and provide descriptors for each level.*
		Can the children use the **feedback to reflect** on their learning process on their own?	The material can contain examples or models that illustrate the expected outcomes or standards of performance for a given task or assignment. For example: • *an example for a math textbook might show how to solve a complex problem using different methods or strategies, and explain the steps and reasoning involved.* • *a model for an English textbook might show a sample essay or paragraph that demonstrates the use of effective writing techniques, such as topic sentences, transitions, evidence, and analysis.* The material includes the correct solutions to the learning problems if they are convergent in nature or a suggestion of possible solutions if they are divergent in nature. The material comprises assessment tests for learners to check for themselves whether they mastered the subject matter.

Learners' reflections on learning

Area	Introduction	Reflection Questions	Indicators
Learners' reflections on learning	The material should actively support the learner's knowledge about different **learning strategies**. The learner should be encouraged by the material to try out different learning strategies and to integrate them into their learning process. Also, the learner should generally be supported on how to **reflect on their learning process** as a whole, regarding their progress, main strengths as well as weaknesses.	Does the material give explanations about and refer to **different learning strategies/ techniques**?	The material suggests different ways to approach the assignments. For example: • *group discussions,* • *learning from text,* • *hands-on experiments,* • *creating videos,* • *story-telling,* • *reciprocal questioning,* • *peer teaching.* The assignments/tasks are not stereotypical, i.e. it is possible to apply different cognitive operations to address the task. For example: • *concept formation (e.g. classifying animals by their characteristics or defining abstract concepts like democracy or justice)* • *problem-solving (e.g. finding the best route to a destination or designing an experiment to test a hypothesis).*
		Does the material actively encourage the learner to individually **reflect on his/ her own learning process**?	The assignments (sometimes) require learners to explicitly describe and/or evaluate their thinking process. For example: • *what steps they took,* • *how they thought about the problem,* • *why they adopted the procedure, or* • *give reasons why they solved the problem in a way they did.* Learners are encouraged to work deliberately with mistakes, either their own or those of their classmates.

Learners' agency

Area	Introduction	Reflection Questions	Indicators
Learners' agency	Within a material, **learners should be considered agents of their own learning path**. The material should enable the learners to express their individuality within the learning process. This is about a learner's needs, but also a learner's **wishes, creativity and boundaries as well as aspects of wellbeing**. This approach is based on inclusion as an ethical standard related to human rights.	Does the material provide a range of opportunities for the learners to **make their own decisions** within their learning process?	The material encourages learners to reflect on their own learning, their strengths and capabilities. For example: • *by addressing the learner directly and taking them seriously, by offering opportunities for self-reflection and dialogue, posing different types of tasks, enable decision making, using encouraging language.* • *by encouraging a learner to opt for another material if they do not find the material they are currently working with helpful.* A material enables learners to generate their own ideas. For example: • *when not everything is directed at a specific learning goal or outcome,* • *a learner is invited to make up more examples/ scenarios for a learning objective on his/her own* • *is asked to engage with the learning objective creatively.* • *a learner is invited to use the language they feel most comfortable in, for example during a writing task.* In order to leverage this kind of agency, the material is committed to transparency. For example: • *by explaining its intentions and learning goals clearly,* • *providing context about learning theories*
		Does the material address the learner as able in **handling and controlling their own learning process**?	Authors of a material communicate learning goals transparently. The material encourages learners not to work on a task if it is categorised as unsuitable for their own learning path/needs. This gives learners control over their own learning path. The material also allows learners to relate to their own environment. For example: • *inviting them to reflect on examples of a topic in their environment (places, animal species, political situation, geographical conditions, etc.).*
		Does the material empower the learner to **critically reflect on the material**?	The material and its authors are committed to the idea of open and participatory further development of materials, e.g. by enabling automatic feedback and providing a space for comments, ratings and reviews.

Area	Introduction	Reflection Questions	Indicators
Learners' agency		Does the material **respect the diversity** of learners overall?	The material reflects the diversity of learners in terms of their identities as well as social, family, cultural, religious and community backgrounds. This is reflected in images and texts that avoid stereotypical or even discriminatory content. Learners, no matter their background, feel seen and respected. • *Pictures/contents mirror the diversity of people in the community. There are no stereotypical, biased or even discriminatory pictures/contents.* • *Cultural and religious diversity is being represented, but not in a stereotypical or biased manner.* • *Diverse perspectives are being represented.* *Issues like racism, sexism, ableism, ageism, and homophobia are not detectable.* The material reflects the diversity of environments and lifeworlds (or it can be adapted easily). • *This is reflected in images and texts that avoid stereotypical or even discriminatory content.* • Aspects like family life, social life, *communities, religion, sexuality etc. are not presented in normative ways.* • *Different social, political, financial backgrounds or places to live (cities, rural areas) are being represented.*

Philosophy

Area	Introduction	Reflection Questions	Indicators
Philosophy	Author(s) of a material should explain its philosophy and conceptions. This implies comments **on design choices and theoretical backgrounds**. Target groups should be made explicit as well as needs the material addresses. Moreover, a material's limitations should be made transparent. Also, the material should clarify how it relates to the national school curriculum. **Reliable sources** should be provided in order prevent mis- and disinformation. Whenever a material claims to be "inclusive", the authors should clarify their **understanding of inclusion** thoroughly.	Does the material give explanations regarding **its set-up, choices and design**? (transparency)	Learning and teaching philosophy/design applied in the material is explained. For example: • *project teaching and learning,* • *on problem-solving,* • *on constructivist ideas in general, it may favour* • *storytelling,* • *case-studies* It is suggested how to use the material. For example: • *mainly as a reference book* • *learning tasks repository* • *comprehensive guide to lessons* • *for the whole class vs. self-study* • *if it is necessary to go through the material systematically, from beginning to end, or, the contrary, it is possible to select parts of the text; the material may be preferably designed for whole-class teaching or can be used for self- study as well).*
		Does the material comment on **intentions and limitations regarding inclusion**?	The material contains specific information directed to the teacher and learners on its content, how it can be used and the key ideas in how it is set up. This includes a definition of inclusion, if inclusion- sensitivity is claimed. The intentions and limitations regarding inclusion and different target groups are mentioned.
		Is the material structured **logically and comprehensible** with a focus on the subject matter?	The material is ordered in a transparent and coherent way. The general idea of learning and teaching, content and core concepts are presented early. A navigation or mapping function supports the understanding of the material's structure. Subject areas are displayed and ordered in logical sub-sub areas. When entering these, there is first information on the topic followed by clarifying videos or other resources. It is always possible to navigate back and to understand where in the material one is at the moment. The material contains *signals* for distinguishing content with different levels of importance and novelty. For example: • *graphical markers (signaling basic content, information to memorize)* • *polygraphic signals (different colours or fonts for certain parts of the text, etc.). At the level of expository text or instructions, this can be, for example, so-called signal words (such as: firstly, secondly..., for example ..., as in ..., as opposed to ..., as compared to ..., the result is...) or advance organizers (like Venn diagram or Fishbone chart to show cause and effect relationships, etc.).*

Area	Introduction	Reflection Questions	Indicators
Philosophy		Is the content represented in the material referring to **valid sources** (against misinformation)?	The content is validated by references and refers to the latest scientific knowledge. References are both old and up-to-date.
		Does the material refer to **curricular requirements and main research results**?	The introduction (or elsewhere in the text) is explicit about the extent to which and how the content of the material covers the curriculum, the syllabus, or which parts of the formal curriculum it relates to.

Astro Pi Mission Space Lab A Meta-review of Science Education Learning Materials

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Abstract:

This meta-review analyzes and discusses the “Astro Pi Mission Space Lab” project and its potential for inclusive learning as perceived by five reviewers, consisting of three teachers, one prospective teacher, and one Astro Pi instructor. These five reviews were prepared based on the “Framework for the Reflection on Living Learning Materials” (FRoLLM), which is an evaluation tool focusing on the analysis of educational materials regarding their inclusion sensitivity, taking into consideration various learners’ needs. This meta-review focuses on the research question of how inclusion and exclusion manifest in the context of the Astro Pi educational materials. Our analysis, based on the five reviews, shows that the Astro Pi materials are perceived as an inspiring initiative provided by European Space Agency (ESA) Education that not only captivates learners with the marvels of space exploration and coding but also offers a unique opportunity to assess and enhance learning materials in innovative educational contexts. At its core, the project combines theoretical science with practical application, as learners design and execute experiments using the Astro Pi computers aboard the International Space Station (ISS). This supports inclusion sensitivity in multiple ways, which are shown and critically discussed in this meta-review.

Keywords:

meta-review; Astro Pi; science education; inclusion sensitivity; FRoLLM evaluation tool

1 Introduction

The evaluation of learning materials is essential for several reasons. It helps teachers determine whether resources meet the diverse needs of learners, accommodate varying levels of prior knowledge, and align with current educational standards. Open Educational Resources (OER) are learning materials that have an open licence, are accessible for everyone, and can be used free of charge (Kreutzer, 2016). This implies usage of the educational material as well as the implementation of changes and further development by its users (UNESCO, 2019). OER play a pivotal role in the success and accessibility of the "Astro Pi Mission Space Lab" project. The open access approach ensures that learners, educators, and teachers—regardless of their prior experience with space science, programming, or the design of experiments—can actively participate (Griffiths et al., 2022) and make meaningful contributions to the project. The evaluation of the Astro Pi educational materials—as well as of other OER-related materials—is of special importance for the impact on educational processes and outcomes since the underlying learning activities and projects build on the impetus to teachers that is made available online. Hence, the quality of the educational materials and their potential for activating learners' engagement with the OER content is decisive for learners' success in learning with these materials (Fischer et al., 2015; Crossfield & Ryan, 2022). This paper focuses on the evaluation of the Astro Pi educational materials with regard to their intentions and limitations to inclusion.

1.1 Introducing the Astro Pi Learning Materials

The digital learning materials discussed in this meta-review were created for the Astro Pi Mission Space Lab (ESA Education, 2024), which is an educational project created and led by the European Space Education Resource Office (ESA, n. d.) in collaboration with the Raspberry Pi Foundation (n. d.). This initiative offers pupils between the ages of 14 and 19 in all ESA member states the opportunity to design and carry out a scientific experiment on board the International Space Station (ISS), using specially adapted computers known as Astro Pis. The subgroup that leads this project in Luxembourg is called the European Space Education Resource Office Luxembourg (ESERO, n. d.), which is a joint project of the European Space Agency (ESA) and the Luxembourg Science Center (LSC), co-financed by the Luxembourg Space Agency and the Ministry of Education (Luxembourg Science Center, n. d.).

As a basis for our analysis, the framework of the Astro Pi materials is briefly outlined in this section. The goal of the Astro Pi Mission Space Lab is to have teams of two students each create a program that captures images of the earth from the International Space Station (ISS), with the intent of using this data to calculate the speed at which the ISS is moving at the time the images are captured. ESERO (n. d.) provides all the materials necessary to carry out this task, including a sample project with historical photos. The three-stage process of the Astro Pi Mission Space Lab is structured as follows. In a first phase, called "Experiment Design," the teams write their Python code, which is then subjected to rigorous testing by ESA to ensure functionality and safety. In the second phase, called "Space Deployment," approved projects are uploaded to the Astro Pi units on board the ISS, where they run autonomously under the supervision of astronauts. The third phase, called "ISS Evaluations," involves data analysis. Once the experiments are completed, the teams receive their data and analyze the results in order to draw conclusions about the speed at which the ISS is moving. The Astro Pi producers state that this three-step process ensures that the complex concepts of space science and technology are accessible while encouraging learners' critical thinking and problem-solving skills (ESA, n. d.; ESERO, n. d.).

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1.2 Brief Description of the Original Reviews

Our meta-review is based on five reviews of the Astro Pi learning materials that were created between October and December 2024. One of the reviews was written by a student in the *Bachelor en Sciences de l'éducation* (BScE) program at the University of Luxembourg, one by a primary school teacher, two by Luxembourg secondary school teachers, and one by an instructor in the Astro Pi program. The reviews were created on the basis of the reflection tool FRoLLM (Framework for the Reflection on Living Learning Materials; see Section 2) against the background of the following question: *How do inclusion and exclusion manifest in the context of the Astro Pi learning materials?* With a focus on this overarching question and based on the five reviewers' prior experiences with the Astro Pi learning materials, two of whom have not yet completed the third phase of implementation (prospective teacher and primary school teacher), not all questions of the FRoLLM catalog could be answered by all reviewers. Therefore, this meta-review does not claim to address all of the FRoLLM questions but aims to identify relevant inter-individual differences as well as striking similarities in the reviewers' assessments.

With this in mind, we aim to develop an idea of the extent to which inclusive potentials are contained in the Astro Pi materials and how further potential can be identified. A constraint that should be mentioned is that for a comprehensive analysis of the Astro Pi Mission Space Lab, the evaluation of the technical content (e.g., programming, data analysis, scientific investigation) would also have to be included. In our meta-review, however, we focus on the didactics and methods with which this technical content is conveyed, as well as on the overarching framework for implementing the Astro Pi materials in learning groups with pupils.

2 Methodology

This meta-review is based on the information provided by five reviewers who each independently evaluated the Astro Pi learning materials. The five reviewers were selected based on the following considerations. In order to receive feedback from different perspectives, a teacher in training and three fully qualified teachers were included in the review process. All teacher and student reviewers are female. The prospective teacher is a higher-semester student in the above-mentioned BScE study program at the University of Luxembourg. Two of the three experienced teachers work at the Luxembourg secondary school, the third is a primary school teacher. One of the secondary school teachers works at a technical secondary school, the other teaches at a general secondary school. In addition, one (male) instructor from the Astro Pi project in Luxembourg was involved in the review process.

The five reviews were created using the FRoLLM evaluation tool, which forms a viable basis for reflection on the "inclusion-sensitivity of educational materials, taking into consideration various learners' needs" (digiLLM, n. d.). The FRoLLM reflection tool consists of six areas, each of which encourages the reviewer to think about the learning materials from a different perspective: *Philosophy, Learners' Environment(s), Learners' Needs, Learners' Reflections on Learning, Learners' Agency,* and *Learning Feedback on Learning*. For each of these areas of reflection, the FRoLLM catalog contains two to five questions (20 in total; digiLLM, n. d.), which are illustrated using practical examples. The FRoLLM review process involves the reviewer firstly expressing their perception of the materials by awarding up to five stars for each question (quantitative feedback) and secondly writing a comment that supplements the quantitative assessment with further information (qualitative feedback).

Due to its clarity and the direct reference to teaching practice, FRoLLM was selected to create the five

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reviews on the Astro Pi learning materials. However, since reflection on questions such as "Does the material address the student as capable of mastering and controlling their own learning process?" (digiLLM, n. d.) requires full implementation of the Astro Pi materials into the teaching process and not all reviewers have yet completed the Astro Pi Mission Space Lab, some questions in the FRoLLM evaluation tool remained unanswered by individual reviewers. In order to synthesize the results of the five reviews, the meta-analysis approach of Cooper et al. (2013) was used, with a particular focus on identifying similarities as well as noticeable differences in the ratings of the five reviewers. We chose this approach for our analysis because it is particularly valuable when dealing with complex or heterogeneous data, such as reviews, where individual ratings may offer differing perspectives. By systematically collecting and comparing data from the five reviews, this approach allowed us to identify overarching patterns and effects across the reviews. To better systematize our analysis, we employed the six FRoLLM reflection areas (see above) to guide the identification of patterns related to the inclusion sensitivity potential of the Astro Pi materials. Comparing both quantitative data (ratings from 1 to 5 stars) and qualitative data (reviewers' written comments) allowed for a more comprehensive interpretation, facilitating the identification of common themes and insights that might not be apparent in individual reviews. Thus, the meta-analysis method proposed by Cooper et al. (2013) provided a rigorous and systematic framework for synthesizing our reviews, enabling us to draw more reliable and generalizable conclusions, particularly when comparing diverse data sources like reviewers' written comments.

We began by collecting relevant information from the five reviews with regard to our overarching research question. Subsequently, we systematically analyzed the content by coding it according to the six FRoLLM reflection areas—namely *Philosophy, Learner's Environment, Learner's Needs, Learner's Reflections on Learning, Learners' Agency,* and *Learning Feedback on Learning*—as outlined on the digiLLM project homepage (digiLLM, n. d.). The reviews were read and reread independently by the two authors until we had a comprehensive understanding of the aspects that would be pertinent for coding. We then assigned the reviewers' ratings to the FRoLLM reflection areas, integrating the findings into a cohesive set of insights. The interpretation of the evidence was guided by qualitative content analysis techniques, as described by Bengtsson (2016), allowing us to identify key themes and patterns in the data. Consequently, our meta-review does not aim to provide a comprehensive representation of all ratings but focuses on identifying salient similarities and differences between the reviews.

3 Analysis and Synthesis

Our analysis and synthesis are based on the five FRoLLM categories that are essential for understanding and enhancing the learning process with digital learning materials. The first category, *Philosophy*, focuses on perspectives on learning and teaching that, providing a framework for understanding how learning occurs in connection with the Astro Pi materials. The second category, *Learners' Agency*, examines how learners can take control of their own learning journey. This includes fostering self-regulation, motivation, and the ability to make informed decisions about their learning paths while using the Astro Pi materials. *Learners' Needs*, the third category, addresses the diverse and individual requirements of learners, encompassing cognitive, emotional, and social aspects. Understanding these needs is essential for tailoring educational approaches that support each learner's development while using the Astro Pi materials. The fourth category, *Learners' Environment*, explores the various contexts in which learning with the Astro Pi materials can take place, including physical spaces, social settings, and digital surroundings. Finally, *Learning Feedback to Learners* synthesizes the reviewers' views on how the feedback

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provided by the Astro Pi materials can help structure the learning process. This refers to providing timely, constructive, and clear feedback that guides learners in improving their performance and understanding. Together, these five FRoLLM categories form the framework for our analysis, which is grounded in the insights derived from the five comprehensive reviews of the Astro Pi learning materials.

3.1 Philosophy and Learners' Agency

Regarding the *Philosophy* of the material, all reviewers agree that Astro Pi has a good or very good structure and design (four to five stars), providing excellent opportunities for project teaching and learning as well as problem solving. The teacher from the technical secondary school emphasizes in her written comment that Astro Pi offers "plenty of online material to help the students […] to start and to complete the project" (Review 3), which in turn allows independent work and supports inclusion-sensitive learning. Specifically, this teacher sees Astro Pi as having great potential for inclusive learning in the STEM field since the materials are linked to "several other resources," such as GitHub[1], which supports possible "solutions and different tools" (Review 3). GitHub as a further resource is evaluated by all reviewers as very good or excellent, especially in regard to opportunities for individualized support. Consequently, one of the secondary school teachers rates the GitHub link as a very "effective collaboration tool" (Review 4) that allows learners to discover science content through diverse learning pathways. While both secondary school teachers point out that the "code is up to date" (Review 3) and that the Astro Pi Mission Space Lab allows students to investigate "a great set of computer knowledge around the Python language" (Review 4), neither the primary school teacher nor the prospective teacher refer to IT-related aspects in their written comments. One of the secondary school teachers, however, emphasizes that Astro Pi allows learners to "discover image processing" (Review 4, *Philosophy*) and makes them consider "other scientific parameters such as the curvature of the earth or the lens of a camera" (Review 4, *Learner's Environment*), thus allowing pupils to incorporate their individual imaginations and previous experiences (*Learners' Needs*).

In her comment on the FRoLLM reflection area for *Philosophy*, the primary school teacher considers it effective that the "Astro Pi learning material allows the teacher to provide additional impulses" when using the material in order to "optimally support the learners in their problem-solving process" (Review 2). The secondary technical school teacher critically evaluates the sheer number of options by noting that the "amount of guides" and information can sometimes be "overwhelming" and that it might be helpful to summarize the content and "provide a starting guide" (Review 3, *Learner's Agency*). All other reviewers rate the possibilities that the Astro Pi materials offer for realizing learners' agency as high or very high.

There are greater differences between the reviews when it comes to the question of whether the materials contain statements about the intentions and limits of inclusion (*Philosophy*). While the prospective teacher considers inclusion sensitivity to be "very present" (Review 1) in the Astro Pi materials, the primary school teacher feels that it is "not so strongly represented" (Review 2). In her comment, the primary school teacher justifies her assessment by explaining that the potential for inclusive learning and teaching is described "rather implicitly in the material" and that she thinks it makes sense to "express the intentions on the topic of inclusion more clearly in the Astro Pi material" (Review 2). Overall, however, the five reviewers' feedback regarding the usability of the Astro Pi material for inclusive teaching is very positive. For example, the individualization possibilities

[1] GitHub empowers developers to modify, adapt, and enhance software from its public repositories under various plans. This flexibility fosters collaboration and innovation within the open source community. The introduction of unlimited private repositories and unlimited collaborators for all users has removed previous limitations, allowing teams to manage their work together in one place. These enhancements provide developers with the tools and resources to innovate and contribute to the open source community.

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(*Learners' Needs*) are rated as excellent (five stars) by all reviewers, a factor that the primary school teacher views as "important for the inclusion of all learners" (Review 2).

3.2 Learners' Needs, Learners' Environment, and Learning Feedback to Learners

It is striking that the assessments of the five reviewers show a particular agreement with regard to the factors relating to the *Learners' Environment*. For example, the teacher at the general secondary school points out that the Astro Pi learning materials facilitate "teamwork" in an excellent way by encouraging learners to "distribute tasks within their team, going as far as setting up and monitoring a schedule" (Review 4). The primary school teacher and the prospective teacher rate the potential for using the materials in various physical and digital learning settings as well as in "different kinds of group work" (Review 2) and "individual work" (Review 1) as very high. Particularly noteworthy is the reviewers' feedback on the question of the availability and free accessibility of the materials in various formats, which is rated as excellent by all five reviewers.

All reviewers agree that the materials contain opportunities for inclusion due to open access to technology. The teacher from the general secondary school states that thanks to the "tutorials" Astro Pi enables learners to (relatively) easily overcome the challenges associated with working on the task, helping them find solutions and "optimize the algorithm" (Review 4, *Learner's Environment*). In his written comment, the Astro Pi instructor explains that the project draws on "widely used technologies" (Review 5), such as the Raspberry Pi programming language and Python, which are "accessible tools that can be found or purchased inexpensively" and that, in turn, make participation "easier for schools and organizations with limited resources" (Review 5). Specifically, the Astro Pi instructor points out the comprehensive educational support from "ESA and the Raspberry Pi Foundation […] through educational materials, tutorials, and online resources" (Review 5). The Astro Pi online access, as described by the instructor, "democratizes access to knowledge" and allows pupils and teachers to learn "to code, design experiments, and analyze data regardless of their prior knowledge" (Review 5). The support options offered by ESA and the Raspberry Pi Foundation are consistently rated as excellent by all five reviewers.

With reference to the reflection areas *Learners' Needs* (including different learning paths) and Learners' Environment (including different types of groups), the Astro Pi instructor perceives the factors of international collaboration and multilingual resources as important for inclusion in the context of digitality. In particular, he considers the Astro Pi Mission Space Lab to be of outstanding importance because it is "open to learners in all ESA member states" (Review 5), supporting multiple languages and promoting international teamwork. This ensures, as the Astro Pi instructor states in his written comment, that language barriers are not an obstacle to using Astro Pi. In line with the instructor's assessment, the prospective teacher and the primary school teacher rate the Astro Pi materials as very good learning materials for all pupils, "regardless of their language skills" (Review 1). In her written comment, the primary school teacher even emphasizes that the "multilingual approach of the material is important for the inclusion of all learners" (Review 2), especially in the multilingual setting of the Luxembourg school system. Similarly, the teacher from the technical secondary school points out the international exposure of the Astro Pi materials, their excellent possibilities for both "self-organized work and working as a team" (*Learner's Environment*), the examination of "established coding standards," such as "failure tolerance, testing or storage usage" (*Philosophy*), and that there is "not one but many possible ways to solve a problem" (Review 3; *Learners' Needs*).

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The ratings from the five reviewers are particularly high (four to five stars) in the area of *Learning Feedback to Learners*, emphasizing the advanced-level peer feedback that is provided by ESA. More critically, the instructor addresses aspects of the *Learners' Environment*, as Astro Pi requires "access to essential technology and the internet" (Review 5), but schools in low-resource areas may have difficulty obtaining Raspberry Pi units, sensors, or reliable internet connectivity for project development and data analysis. In his review, the instructor also considers the potential skill gap regarding coding and technical expertise, pointing out that some learners and/or teachers "may not have sufficient digital literacy skills to start working on the project" (Review 5, *Learners' Needs*), especially in "regions where computer science education at school is not well-established" (Review 5, *Learners' Environment*). This can exclude groups that are less familiar with programming and technical problem solving, as the instructor points out. Lastly, he reflects on accessibility barriers and states that some learners with special educational needs may find the Astro Pi project challenging, if the "educational materials and programming environments are not fully adapted to their needs" (Review 5, *Learners' Needs*). While ESA's efforts include basic accessibility considerations, specialized support for adaptive technologies or alternative learning formats could be expanded even further, the instructor concludes.

4 Discussion

Based on this analysis, it can be concluded that Astro Pi provides very good opportunities for learning in the STEM field of space sciences and technology. In line with the producers' statement (see Section 1.3), the five reviewers confirm that the three stages of the learning process with Astro Pi ensure that the complex concepts of space science and technology are accessible and stimulating, ultimately promoting the participation of all learners. Based on the analysis of the five reviews, it can be summarized that the Astro Pi project promotes teamwork and innovation while developing learners' coding, data analysis, and scientific research skills. Viewed from a content perspective, this is in line with ESA's mission to inspire and train the next generation of scientists, engineers, and space enthusiasts (cf. ESA Education, 2024). Furthermore, based on the reviewers' feedback, we can conclude that Astro Pi not only opens doors for content-related learning but also provides inclusive learning opportunities through individualized feedback for each learning group and hence supports learning on different levels and various learning paths.

If we look at the analysis from the perspective of the question of how inclusion and exclusion manifest in the context of the Astro Pi learning materials, two aspects must be taken into account. First, the factor of lowering barriers to entry needs to be addressed. The analysis of the five reviews showed that the Astro Pi project offers limited support options for pupils with special educational needs, such as blind or visually impaired learners. While the Astro Pi materials provide valuable resources like freely accessible guides, tutorials, and templates to support and challenge learners individually, their accessibility for blind and partially sighted learners is suboptimal. However, resources include step-by-step instructions for designing experiments, programming in Python, and understanding the hardware and sensors of the Astro Pi computers. This makes the project accessible for beginners and yet exciting for advanced participants.

This brings the second focus of the discussion into play, namely the promotion of equity and inclusion. By offering resources at no cost, the Astro Pi Mission Space Lab ensures that schools, youth groups, and communities with limited funding for STEM education can participate. The professional and free support from ESA, as emphasized by all reviewers, ensures that teachers without in-depth IT knowledge can fully participate in the Astro Pi project with their classes. In addition, the availability of the materials in multiple languages aims at the inclusion of all learners and

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is in line with ESA's goal of reaching students with different language competencies in its various member states (cf. ESA Education, 2024). The critical point to be made, however, is that individualized support for learners with special educational needs is not provided by the material. Yet, since the description of the Astro Pi materials does not indicate that it aims to actively support learners with special educational needs, this cannot be viewed as criticism of the materials but rather as an outlook for possible additions and future development.

In summary, with regard to inclusion and accessibility, the reviews show that there are two different perspectives on the Astro Pi materials. On the one hand, the reviews reveal the importance of access to the program being free and open to both the formal (e.g., secondary schools) and informal sector (e.g., youth organizations, afternoon childcare centers), so that learners from different educational institutions can participate. On the other hand, the aim of reaching out to as many young people as possible is supported by the fact that neither learners nor teachers need to have special prior knowledge regarding programming. Therefore, anyone interested can take part in the Astro Pi project and contribute according to their individual prior knowledge. This allows the participation of various learners at different levels of competence and offers incentives for both the learner with previous knowledge of programming and the learner who has never worked with this programming language before.

According to the reviews, the Astro Pi Mission Space Lab not only appears to empower pupils to engage with real-world science and space exploration, but the learning materials also seem to have the potential to instill a sense of wonder and curiosity about the universe. By conducting experiments aboard the ISS, pupils gain hands-on experience that bridges the gap between classroom learning and the latest in space science. It cannot be ruled out that using an analysis instrument other than FRoLLM might have revealed different results, as aspects such as appropriate grammar and terminology are not as prominently emphasized in FRoLLM as they are in other instruments for learning material evaluation (cf. Suartama, 2020). In addition, in order to better reflect the Astro Pi material, it is recommended to include a larger number of reviews and also to give a voice to pupils, both in primary and secondary school.

5 Conclusion

The Astro Pi learning materials provide a unique educational experience that allows young people to experience a real science mission and learn about the technologies used in space exploration. Through this project, pupils develop skills in programming, data analysis, and problem solving while exploring scientific concepts related to space motion and orbit. Overall, this meta-review shows that a systematic evaluation process provides valuable feedback that can lead to continuous improvement. By examining the impact of the materials on learners' educational processes and outcomes, teachers and curriculum developers can identify strengths, pinpoint areas for enhancement, and adapt strategies to better support learning. The reflection tool FRoLLM provides an important basis for such a systematic analysis process, allowing users to weigh in on the learning materials as well as the materials' producers and curriculum developers. Such an iterative feedback loop not only enhances learners' engagement and achievement in projects like Astro Pi but also contributes to the broader evolution of STEM education.

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Interaktives Tafelbild – Symmetrie: Meta-Review eines Lernmaterials für den Mathematikunterricht an Grundschulen

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Abstract:

This meta-review examines the strengths and weaknesses of an Open Educational Resource (OER) developed for primary school teaching. This resource is published via the Siemens Stiftung's media portal and focuses on the topic of symmetry (Siemens Stiftung, n.d.). The starting point for this meta-review are six qualitative reviews, each of which examines the media package for inclusion sensitivity using the "Framework for the Reflection on Living Learning Materials" (FRoLLM) that was developed in the digiLLM project (digiLLM, n.d.). The data collected was first structured (Poscheschnik & Lederer, 2020) and then examined in a comparative analysis to identify both similarities and differences in the learning material evaluations. The meta-review shows that although some elements of inclusion sensitivity have already been partially implemented, the media package as a whole is not suitable for inclusive mathematics teaching. There is little room for improvement regarding the learners' environment, but feedback formats and encouragement for critical reflection on the learning material and process are lacking. Therefore, teachers need to adapt the material to students' individual needs before using it in primary school teaching. Overall, there are also differences in the evaluation. Five of the six reviewers agree that the media package is not inclusive. However, one reviewer perceives it as inclusive. Despite defined criteria, the evaluation of learning materials therefore continues to be influenced by personal assessments.

Keywords:

meta-review; Open Educational Resources (OER); inclusion sensitivity; inclusive teaching concept for mathematics; evaluation of learning materials

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Interaktives Tafelbild – Symmetrie: Meta-Review eines Lernmaterials für den Mathematikunterricht an Grundschulen

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Zusammenfassung:

Der folgende Meta-Review untersucht die Stärken und Schwächen einer für den Grundschulunterricht entwickelten Open Educational Resource (OER). Diese stammt aus dem Medienportal der Siemens Stiftung und behandelt das Thema *Symmetrie* (Siemens Stiftung, o.J.). Ausgangspunkt für diesen Meta-Review sind sechs qualitative Reviews. Diese untersuchen jeweils auf Grundlage des im digiLLM-Projekt entwickelten „Framework for the Reflection on Living Learning Materials“ (FRoLLM) (digiLLM, o.J.) das Medienpaket auf Inklusionssensibilität. Die erhobenen Daten wurden im ersten Schritt strukturiert (Poscheschnik & Lederer, 2020) und anschließend in einer vergleichenden Analyse betrachtet, sodass Gemeinsamkeiten und Unterschiede der Lernmaterial-Evaluationen aufgedeckt werden konnten. Der Meta-Review zeigt, dass das Medienpaket insgesamt nicht für den inklusiven Mathematikunterricht geeignet ist, Elemente der Inklusionssensibilität jedoch teilweise umgesetzt sind. Besonders im Bereich „*Die Umgebung der Lernenden*“ gibt es wenig Verbesserungspotenzial. Ein großer Bedarf besteht hingegen darin, das Material an die individuellen Bedürfnisse der Lernenden anzupassen, um es im Grundschulunterricht einsetzen zu können. Dazu fehlen Feedbackformate und eine Anregung zur kritischen Reflexion des Lernstoffs und -prozesses. Lehrkräfte sollten daher vor Nutzung dieses Materials Anpassungen und Ergänzungen vornehmen. Insgesamt zeigen sich außerdem Unterschiede in der Bewertung. Fünf der sechs Befragten stimmen dafür, dass das Medienpaket nicht inklusiv ist. Eine Reviewerin nimmt es jedoch durchaus als inklusiv wahr. Trotz festgelegter Kriterien ist die Lernmaterial-Evaluation deshalb weiterhin durch persönliche Einschätzungen geprägt.

Schlagworte:

Meta-Review, Open Educational Resources (OER), Inklusionssensibilität, inklusiver Mathematikunterricht, Lernmaterial-Evaluation

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1 Einleitung

Viele Lehrkräfte sind zum gegenwärtigen Zeitpunkt mit der schulischen Situation überfordert (Robert Bosch Stiftung, 2024). Einerseits etabliert sich in der Schule eine „Kultur der Digitalität“ (Stalder, 2016), die viele Herausforderungen für Lehrkräfte beinhaltet, andererseits nimmt die Heterogenität in den Klassen zu, weshalb Inklusionssensibilität zunehmend an Bedeutung gewinnt. Dies führt erstens dazu, dass Lehrkräfte immer mehr auf inklusionssensible Materialien angewiesen sind, um alle Schüler:innen mit ihren spezifischen Fertigkeiten und Fähigkeiten wahrzunehmen und sie dementsprechend zu fördern und zu fordern (Kron, 2010). Zweitens führt dies zu veränderten Handlungsweisen der Lehrkräfte, die digitale Medien beispielsweise zur Differenzierung einsetzen, und drittens zu einer kontinuierlichen Adaption des Unterrichtsmaterials an das Niveau der jeweiligen Lerngruppe (Budde, 2011). Aufgabe der Lehrkräfte ist es vor allem, mit Hilfe von geeignetem Unterrichtsmaterial einen heterogenitäts- und inklusionssensiblen Unterricht zu planen und durchzuführen (Brückner, 2018). So kann auf verschiedene Charaktereigenschaften und Heterogenitätsdimensionen, etwa die Lernvoraussetzungen der Schüler:innen, Rücksicht genommen und an die einzelnen Bedarfslagen angeknüpft werden – mit dem Effekt, dass alle im Unterricht am gemeinsamen Gegenstand lernen können (Vogt, 2022). Im Sinne dieser inklusiven Ausrichtung fokussiert das Projekt digiLLM die Inklusionssensibilität von digitalen Lehr- und Lernmaterialien. Im Rahmen des Projekts wurde ein „*Framework for the Reflection on Living Learning Materials*“ (FRoLLM) entwickelt, das es verschiedenen Personengruppen ermöglicht, Unterrichts- und Lernmaterialien kriteriengeleitet auf ihre Inklusionssensibilität zu untersuchen (digiLLM, o.J.).

Der Meta-Review, um den es im Folgenden gehen soll, führt sechs Reviews zusammen, die auf dem FRoLLM basieren. Sechs Personen, davon drei Grundschullehramtsstudentinnen der Universität Bielefeld und drei Lehrkräfte aus Bielefeld, haben das Medienpaket anhand des FRoLLM-Worksheets (digiLLM, o.J.) untersucht und bewertet. In ihren Reviews werden die Stärken und Schwächen eines für den Mathematikunterricht – Schwerpunktthema ist hier Symmetrie – konzipierten Medienpakets der Siemens Stiftung (Siemens Stiftung, o.J.) im Hinblick auf seine Inklusionssensibilität beleuchtet. Die Forschungsfrage dieses Meta-Reviews lautet daher wie folgt: *Inwiefern eignet sich das Medienpaket der Siemens Stiftung zum Thema Symmetrie für den inklusiven Mathematikunterricht?* Vor dem Hintergrund dieser Frage wurden Gemeinsamkeiten und Unterschiede der Reviews herausgearbeitet sowie die Eignung der Lernmaterialien für den inklusionssensiblen Unterricht reflektiert. Darüber hinaus ermöglicht der Meta-Review, Weiterentwicklungsmöglichkeiten aufzuzeigen, anhand derer eine Aufwertung des Medienpakets vorgenommen werden kann. Die verschiedenen Evaluationen werden einander im Folgenden daher gegenübergestellt und verglichen. Dabei stehen diejenigen positiven und negativen Aspekte des Medienpakets im Fokus, die für oder gegen gelingenden inklusionssensiblen Unterricht sprechen. So trägt der Meta-Review dazu bei, einen Überblick über die möglichen Einsatzszenarien des Medienpakets zu erhalten. Er zeigt Lehrkräften auf, welches Potenzial darin liegt, und weist zugleich auf Aspekte hin, die vor dem Einsatz im Unterricht zu beachten sind, einschließlich erforderlicher Anpassungen.

Im ersten Schritt werden der Untersuchungsgegenstand und das methodische Vorgehen erläutert. Anschließend erfolgt die Auswertung der Ergebnisse. Das Augenmerk liegt dabei auf einer vergleichenden Analyse nach Pickel (2016), in deren Verlauf Unterschiede und Gemeinsamkeiten der Evaluationen aufgezeigt und Hypothesen generiert werden. Daran knüpft eine Diskussion an. Den Abschluss der Arbeit bildet ein Fazit.

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2 Empirische Erhebung

Dieser Abschnitt vermittelt einen Überblick über der Meta-Review per se. Dabei werden sowohl der Untersuchungsgegenstand – d. h. das Materialpaket für den Mathematikunterricht – als auch das methodische Vorgehen erläutert.

2.1 Untersuchungsgegenstand

Grundlage des Meta-Reviews ist ein digital verfügbares Medienpaket, das im Medienportal der Siemens Stiftung (Siemens Stiftung, o.J.) zum kostenlosen Download bereitsteht. Es wurde als Open Educational Resource (OER) veröffentlicht und besteht ausschließlich aus Materialien für den Mathematikunterricht in der Grundschule. Thema sind Achsen-, Schub- und Drehsymmetrie. Das Medienpaket ist in den Sprachen Deutsch, Englisch und Spanisch abrufbar und besteht aus insgesamt 22 Einzelmedien, darunter interaktive Bilder, Übungen, Arbeitsblätter sowie eine Animation. Die Materialien wurden zwischen 2015 und 2021 veröffentlicht und später zu einem Medienpaket gebündelt. Sie können online verwendet werden, doch es besteht auch die Möglichkeit, sie auszudrucken. Informationen für Lehrende, z. B. in Form von Leitfäden, die einen Überblick über die inhaltlichen und didaktischen Zusammenhänge der jeweiligen Medien bieten, sind ebenfalls enthalten (Siemens Stiftung, o.J.).

Als qualitative Daten, die mittels eines Meta-Reviews ausgewertet wurden, dienen die von den Befragten ausgefüllten FRoLLM-Worksheets (digiLLM, o.J.). Jedes dieser Worksheets umfasst die sechs Bereiche „*Reflexion der Lernenden über das Lernen*“, „*Bedürfnisse der Lernenden*“, „*Umgebung der Lernenden*“, *Lernfeedback für Lernende*“, „*Selbstwirksamkeit*“ und „*Philosophie*“. Diese Bereiche beinhalten verschiedene Fragen und fördern die Reflexion der Inklusionssensibilität. Darüber hinaus fragt das Worksheet allgemeine Informationen zu den untersuchten OER ab und fordert zur abschließenden Bewertung des Materials als inklusiv oder nicht inklusiv auf.

2.2 Methodisches Vorgehen

Insgesamt wurden sechs schriftliche Reviews untersucht. Diese stammen von drei Grundschullehramtsstudentinnen der Universität Bielefeld und drei Grundschullehrkräften aus Bielefeld. Alle evaluierten mittels des FRoLLM-Worksheets das bereits geschilderte Medienpaket zum Thema Symmetrie (Siemens Stiftung, o.J.). Nachdem die Teilnehmenden die ausgefüllten Worksheets eingereicht hatten, wurden diese systematisch aufbereitet und kategorisiert (Poscheschnik & Lederer, 2020), sodass anschließend eine vergleichende Analyse nach Pickel (2016) durchgeführt werden konnte. Die Ergebnisse werden im Folgenden entsprechend der Reihenfolge der Fragen auf dem Worksheet dargestellt. Durch die vergleichende Analyse der Inhalte wurden Hypothesen generiert sowie Unterschiede und Gemeinsamkeiten der Evaluationen aufgedeckt, sodass die Anwendbarkeit des Materials im Grundschulunterricht datenbasiert evaluiert werden konnte.

3 Ergebnisse

Nachdem der Untersuchungsgegenstand und das methodische Vorgehen vorgestellt wurden, werden nun die Ergebnisse dargelegt und schrittweise vergleichend betrachtet, sodass als Ergebnis Hypothesen formuliert werden können. Grundlage sind die qualitativen Reviews der drei Studentinnen (S1–S3) und Lehrkräfte (L1–L3).

3.1 Reflexion der Lernenden über das Lernen

Der erste Bereich des FRoLLM-Worksheets umfasst zwei Reflexionsfragen, die von allen Befragten ähnlich beantwortet wurden. Bei der Frage „*Enthält das Material Erklärungen zu und Hinweise auf verschiedene Lernstrategien/-techniken?*“ kamen die Befragten zu dem Schluss, dass „[e]in […] Themenfeld […] die Schubsymmetrie [ist]. Sie wird den Kindern erklärt

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und die Kinder können dazu ein Arbeitsblatt bearbeiten. Lernstrategien oder Techniken fehlen hier“ (L1). S1 ergänzt: „Es werden verschiedene Aufgabentypen genutzt, die verschiedene Lernstrategien ansprechen, aber es werden keine Erklärungen oder Hinweise gegeben.“ Lediglich eine Studentin ist gegensätzlicher Meinung und schreibt: „Das vorliegende Material bietet Hinweise auf verschiedene Lernstrategien und -Techniken, indem es eine Vielfalt an Arbeitsbereichen umfasst. Diese Bereiche sind Bilder, Interaktives und Texte“ (S2).

Die zweite Frage, „*Regt das Material den Schüler aktiv dazu an, seinen eigenen Lernprozess zu reflektieren?*“, wurde von fünf Teilnehmer:innen verneint. „[E]s regt auch nicht dazu an, den Lernprozess zu reflektieren“, konstatiert etwa S3, während S1 schreibt: „Eher nicht, weil es keine Aufgaben gibt, die auf andere folgen oder als Voraussetzung gesehen werden und somit den Lernprozess deutlich machen würden.“ Auch in diesem Fall differiert die Meinung von S2. Sie geht davon aus, dass eine aktive Anregung indirekt geschieht, „denn [das Material] bietet den Kindern dennoch die Möglichkeit, selbst zu differenzieren und herauszufinden, welche Strategie für sie am effektivsten ist. Dies unterstützt die Individuelle Lernentwicklung und fördert die Selbstständigkeit im Lernprozess.“ Dies spiegelt sich auch in der Sternebewertung wider. Vier der Befragten (S1, L1, L2, L3) vergeben zwei, eine Studentin vergibt in diesem Reflexionsbereich einen (S3) und die Studentin mit gegensätzlicher Meinung sogar vier Sterne (S2).

Aus den Aussagen der Befragten lässt sich ableiten, dass das Medienpaket im Bereich „*Reflexion der Lernenden über das Lernen*“ vor der Nutzung im Unterricht überarbeitungsbedürftig ist. Es ist anzunehmen, dass es in seiner aktuellen Form nicht ausreichend zur Förderung der Reflexionsfähigkeit der Lernenden beiträgt. Eine gezielte Ergänzung um Reflexionsanreize würde die Selbstreflexion der Schüler:innen mit großer Sicherheit erheblich verbessern.

3.2 Bedürfnisse der Lernenden

Die erste Frage dieses Reflexionsbereichs, „*Bietet das Material verschiedene Lernwege/Aufgaben für den gleichen Stoff in unterschiedlicher Komplexität?*“, wird von zwei Studentinnen (S1, S2) bejaht. S1 erklärt: „Ja, weil es zu den digitalen Aufgaben auch analoge Bastelalternativen gibt, und die Bastelaufgaben bieten oft verschiedene Niveaus an.“ Die dritte Studentin verneint jedoch und urteilt: „Das Lernmaterial ist sehr einseitig. Differenzierungsmöglichkeiten gibt es kaum zu einer Aufgabe oder Material, die müsste man sich als Lehrkraft in dem Fall selber ausdenken“ (S3).

Alle Lehrkräfte beobachten, dass nur der innerhalb des Medienpakets als „*Basteleien mit…*“ gekennzeichnete Bereich Aufgaben mit verschiedenen Komplexitätsstufen enthält, denn dort „werden weitere Bastelmöglichkeiten angeregt“ (L2) und „verschiedene Aufgaben“ (L3) angeboten. Drei der Reviewer:innen vertreten außerdem die Ansicht, dass das Medienpaket keine unterschiedlichen Stufen der Unterstützung bietet, die es ermöglichen, die Materialien an den Grad eventueller Lernschwierigkeiten anzupassen (S3, L2, L3). Allerdings konstatieren eine Lehrkraft und eine Studentin (S1, L1), dass durch die im Paket enthaltenen Medien teilweise Unterstützung geboten wird, etwa in Form farbiger Bilder (L1).

Bei der nächsten Reflexionsfrage, „*Gibt es verschiedene Arten der Darstellung des Lernstoffs, die an die unterschiedlichen Bedürfnisse der Lernenden angepasst sind (UDL, Inclusive Design Guide)?*“ ist die Meinung gespalten. Drei der Befragten stimmen zu (S1, S2, L1) und verweisen u. a. darauf, dass der Lernstoff visuell dargestellt oder durch aktives Entdecken bzw. kreatives Gestalten vermittelt wird (S2). Die Übrigen stimmen nicht zu, denn „Unterstützungsmöglichkeiten in dem Sinne […] [wurden] keine gefunden genauso wie verschiedene Darstellungen des Lernstoffs“ (S3). Dass das Material durch Veränderung an individuelle Bedürfnisse angepasst werden kann, verneinen zudem fünf der Befragten. L1 äußert,

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dass Material und Aufgaben fest vorgegeben und somit nicht veränderbar sind. Eine Studentin findet allerdings, dass individuelle Anpassungen zum Teil möglich sind, denn bei den „Aufgaben, bei denen die Kinder selbst etwas ausprobieren […] [gibt es] die Möglichkeit, eigenständig zu arbeiten und die Komplexität […] [des] Arbeitsprozesses […] [und] Endproduktes selbst zu bestimmen […]. Dies ermöglicht eine flexible Anpassung an die unterschiedlichen Lernniveaus“ (S2). Bei der Sternebewertung vergeben alle Lehrkräfte einen oder zwei Sterne (L1, L2, L3), während die Studentinnen einen (S3), drei (S1) und vier (S2) vergeben.

Insgesamt lässt sich aus den Aussagen der Befragten ableiten, dass das bestehende Medienpaket in einzelnen Inklusionsaspekten bereits Ansätze zur Differenzierung aufweist, es jedoch einer gezielten Erweiterung um verschiedene Komplexitätsstufen, Unterstützungsangebote und Darstellungsformen bedarf, um eine breitere Adaptierbarkeit an individuelle Lernausgangslagen zu gewährleisten. Es ist anzunehmen, dass eine solche Anpassung die Zugänglichkeit und Effektivität des Materials im inklusiven Mathematikunterricht signifikant verbessern würde.

3.3 Die Umgebung der Lernenden

Die Befragten sind der Ansicht, dass das Material zwar für die Einzelarbeit gedacht ist, teilweise aber auch Partner:innen- und Gruppenarbeiten möglich sind. Eine Begründung dafür lautet wie folgt: „Die meisten Aufgaben lassen sich für Gruppenarbeit oder für Einzelarbeit verwenden, z. B. Material Schubsymmetrie – Symmetrie durch Verschieben von Mustern Aufgabe 4: lässt sich prima als Gruppenaufgabe durchführen“ (S3).

Die Reflexionsfrage „*Kann das Material in verschiedenen physischen und digitalen Lernumgebungen verwendet werden?*“ wurde von allen Studentinnen und einer Lehrkraft bejaht (S1, S2, S3, L3). S1 notiert dazu: „Ja, die Materialien sind online über den Link verfügbar und die Bastelaufgaben benötigen keine besonderen Materialien.“ Laut L2 gibt es allerdings technische Schwierigkeiten bei digitalen Tafelbildern, da diese nicht auf Tablets geöffnet werden können. Eine Lehrkraft enthält sich, da ihr – laut eigener Aussage – nicht bewusst ist, was physische und digitale Lernumgebungen sind (L1). Die Gesamtgruppe ist außerdem der Meinung, dass das Medienpaket frei zugänglich und in verschiedenen Formaten verfügbar ist. Als Beispiel für die Formatvielfalt wird angeführt, dass die Arbeitsblätter ausgedruckt werden können (L2).

Die Sternebewertung spiegelt verschiedene Meinungen wider. Jeweils eine Lehrkraft und eine Studentin vergeben zwei (S2, L1), drei (S3, L2) und vier Sterne (S1, L3).

Insgesamt machen die Aussagen der Befragten deutlich, dass das Material in verschiedenen Sozialformen sowie physischen und digitalen Lernumgebungen einsetzbar, frei zugänglich und in verschiedenen Formaten verfügbar ist. Der als gering identifizierte Verbesserungsbedarf am Medienpaket deutet darauf hin, dass die Reviewer:innen aus dieser Perspektive mit den bereitgestellten Materialien zufrieden sind und sich zutrauen, diese effektiv zu nutzen.

3.4 Lernfeedback für Lernende

In diesem Bereich sind sich die Befragten einig: Sie alle sind der Ansicht, dass Feedback nur in sehr geringem Maß bzw. gar nicht gegeben wird. „Ich habe bei dem Material keine Art von Feedback gefunden“, konstatiert etwa eine Lehrkraft (L1). S3 konkretisiert: „Feedbackformate sind in den Materialien an sich nicht vorhanden, weder für Selbsteinschätzungen, noch für Peer-Feedback.“ Laut S2 sind jedoch begrenzte Rückmeldeangebote vorhanden. Es kann z. B. eine „Lösung angezeigt werden. […] Diese Rückmeldung erlaubt es den Kindern, ihre Antwort zu überprüfen und gegebenenfalls zu korrigieren. Auf verschiedene Feedbackformate wird nicht hingewiesen.“

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Dennoch kommen alle Reviewer:innen zu dem Urteil, dass die Schüler:innen das Feedback nicht nutzen können, um ihren Lernprozess zu reflektieren. Das ist vor allem der Tatsache geschuldet, dass beim Anzeigen der Lösung „eine tiefere Erklärung [fehlt], die den Kindern vermittelt, warum ihre ursprünglichen Antworten falsch waren und welche Denkfehler eventuell vorlagen“ (S2).

Die Sternebewertung unterstützt diese Aussagen. Fünf der Befragten (S1, S3, L1, L2, L3) vergeben einen Stern, nur eine einzige Studentin vergibt zwei Sterne (S2).

In diesem Reflexionsbereich offenbaren die Reviews also ein enormes Defizit der Materialien: Diese enthalten keine Vorschläge oder integrierten Formate für Feedbackprozesse. Zwar können Lehrkräfte Feedback einbinden, doch müssen sie dafür ohne Vorlagen und Anregungen im Materialpaket selbst geeignete Formate entwickeln. Das legt die Schlussfolgerung nahe, dass die Integration einer systematischen und unterstützenden Feedbackstruktur in das Materialpaket die Reflexion des Lernprozesses seitens der Schüler:innen gezielt fördern und somit die Lernleistung verbessern könnte.

3.5 Selbstwirksamkeit

Die Frage, ob die Schüler:innen die Möglichkeit haben, im Rahmen des Lernprozesses eigene Entscheidungen zu treffen, wird in den sechs Reviews differenziert beantwortet. Zwei Lehrkräfte und eine Studentin (S3, L1, L2) benennen „*Basteleien mit…*“ als einen Bereich, innerhalb dessen Lernende verschiedene Entscheidungen treffen können. L1 schreibt dazu: „Im Bereich ‚Basteleien‘ ist dieses zum Teil möglich. Hier werden die Kinder zum Experimentieren aufgefordert und können so selbstständig Entdeckungen machen.“ Eine weitere Studentin bejaht die Reflexionsfrage, da die Kinder „die Freiheit haben, ihre Aufgaben und den Zeitpunkt zu wählen, zu dem sie diese lösen möchten, [demnach] können die Kinder den Lernprozess nach ihren eigenen Bedürfnissen und Fähigkeiten gestalten“ (S2). Die übrige Studentin und Lehrkraft verneinen jedoch kategorisch, denn „die Aufgaben werden vorgegeben“ (L3).

Die zweite Frage dieses Reflexionsbereichs, „*Spricht das Material den Schüler oder die Schülerin als fähig an, den eigenen Lernprozess zu steuern und zu kontrollieren?*“, wird von den Reviewer:innen ebenfalls differenziert betrachtet. Die Hälfte der Befragten verneint, weil „Kontrollblätter nicht vorhanden sind“ (L1) und „es […] vorgegebene Aufgaben [gibt]“ (S1). Die andere Hälfte vertritt hingegen die Ansicht, dass die Schüler:innen ihre Lernprozesse zumindest teilweise selbst steuern können (S2, S3, L2). Dass das Material die Schüler:innen zur kritischen Reflexion des Lernstoffs anregt, verneinen jedoch alle Befragten. S1 und L3 beantworten diese Frage lediglich mit einem knappen „Nein“, während L1 ausführt: „Die Kinder müssen sich auch nicht kritisch mit dem Stoff auseinandersetzen.“ Drei der Befragten (S2, L1, L3) merken außerdem an, dass durch die Zusammensetzung des Materialpakets verschiedene Lernhintergründe berücksichtigt werden, da unterschiedliche Aufgabentypen und Komplexitätsstufen enthalten sind. Eine Studentin (S3) verneint dies jedoch. Eine andere (S1) kommt zu dem Urteil, dass die Vielfalt der Lernhintergründe teilweise berücksichtigt wird.

Die Sternebewertung zeigt Einigkeit bei den Lehrkräften – sie vergeben jeweils zwei Sterne (L1, L2, L3). Die Studentinnen vergeben indes einen (S1), drei (S3) und vier Sterne (S2).

Insgesamt zeigen die Reviews, dass auch im Bereich „*Selbstwirksamkeit*“ Überarbeitungsbedarf besteht. Die Verbesserung der Selbstwirksamkeit der Schüler:innen durch das Schaffen von Freiräumen für eigene Entscheidungen sowie durch die Steuerung des eigenen Lernprozesses und kritische Reflexion des Lernstoffs würde wahrscheinlich zu einer höheren Lernmotivation und besseren Lernergebnissen führen. Auffällig ist zudem, dass einige Reviewer:innen

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bestimmte Aspekte zwar benennen, sie jedoch nicht explizit bewerten. Dies deutet darauf hin, dass diese Aspekte zwar als relevant wahrgenommen werden, die Befragten sich in ihrer Einschätzung jedoch zurückhalten und ggf. unsicher sind.

3.6 Philosophie

Ein Großteil der Reviewer:innen ist sich einig, dass das Material Erklärungen zu Aufbau, Auswahl und Gestaltung enthält. L2 weist darauf hin, dass „im Leitfaden für die Lehrkräfte" Erklärungen zu Aufbau, Auswahl und Gestaltung des Materials aufgeführt werden. Eine Studentin ist allerdings vom Gegenteil überzeugt: „das Material ist nicht transparent", findet sie (S3).

Alle sechs Reviews sind sich jedoch einig, dass Absichten und Einschränkungen des Materials hinsichtlich Inklusion nicht explizit thematisiert werden. „[E]s wird in keinem Material auf die Absichten und Einschränkungen hinsichtlich Inklusion eingegangen", fasst eine Studentin zusammen (S3). Eine andere Studentin führt zudem aus, dass eine Anleitung dazu fehlt, wie das Material angepasst oder im inklusiven Unterricht genutzt werden kann (S2). Dass der Stoff logisch aufgebaut, verständlich und themenorientiert ist, bejahen hingegen fünf der Befragten. L3 schreibt: „Ja, die Symmetrie wird erst eingeführt und daraufhin gibt es weiterführende Aufgabenformate." Eine andere Lehrkraft widerspricht dieser Ansicht jedoch dahingehend, dass Schubsymmetrie im Mathematikunterricht der Grundschule kein Thema ist und Drehsymmetrie nur bedingt aufgegriffen wird (L1).

Die vierte Reflexionsfrage, „*Bezieht sich der im Material dargestellte Inhalt auf gültige Quellen?*", wird von drei Befragten verneint, da „keine Quellenangaben wahrgenommen" wurden (L3). Die anderen (S2, S3, L2) enthalten sich. Die letzte Frage, „*Bezieht sich das Material auf die Anforderungen des Lehrplans und die wichtigsten Forschungsergebnisse?*", wird indes von fünf Befragten bejaht. Als Beispiele für eine Orientierung am Lehrplan werden die Bereiche „Achsensymmetrie" (S3) und „Zeichnen und Spiegeln von Figuren" (S2) genannt. Eine Lehrkraft sieht nur wenige Anknüpfungspunkte, da wichtige Elemente wie die aktive Entdeckung der Umwelt und der Vergleich von Symmetrien fehlen (L1). Entsprechend der unterschiedlichen Argumentation gibt es differente Sternebewertungen. Drei der Reviewer:innen (S1, L2, L3) geben drei Sterne, eine Lehrkraft gibt zwei (L1) und eine Studentin (S3) nur einen Stern.

Auch in diesem Bereich wird anhand der Reviews sichtbar, dass das Materialpaket überarbeitungsbedürftig ist und vor dem Einsatz im Unterricht adaptiert werden sollte. Es liegt nahe, dass eine Anpassung des Lehrmaterials hinsichtlich Inklusion und Grundschulrelevanz zur effektiveren Nutzung des Materials und Verbesserung des Lernengagements der Schüler:innen führen würde. Auch die Integration aktiver Entdeckungsprozesse würde aller Wahrscheinlichkeit nach zu einer solchen Verbesserung beitragen.

4 Abschließende Bewertung des Medienpakets

Fünf der sechs Befragten bewerten das untersuchte Medienpaket als nicht inklusiv. „Themenschwerpunkte der Symmetrie werden nicht geordnet angeboten" (L1), die Aufgabenstellungen sind nur lesbar und nicht hörbar (S1) und das Materialpaket lässt generell nur ein geringes Maß an Differenzierung zu (S3). Für eine Studentin überwiegen jedoch die Aspekte, die für eine Bewertung als inklusive OER sprechen, da im Material u. a. verschiedene Lernwege berücksichtigt werden und Aufgaben nach „individuellen Interessen und Fähigkeiten" (S2) bearbeitet werden können.

Insgesamt zeigt die Analyse mit dem FRoLLM, dass das Medienpaket einerseits Potenzial und andererseits enorme Lücken aufweist. Positiv zu sehen ist, dass das Material in verschiedenen Sozialformen sowie physischen und digitalen Lernumgebungen

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nutzbar, frei zugänglich und in verschiedenen Formaten verfügbar ist. Außerdem werden Erklärungen zu Auswahl, Aufbau und Gestaltung der Einzelmedien und ihrem möglichen Einsatz im Unterricht gegeben.

Als inklusionssensibel kann das Materialpaket jedoch nicht gelten. Vor dem Hintergrund des Bereichs „*Reflexion der Lernenden über das Lernen*“ bedarf es einer umfassenden Überarbeitung, in deren Kontext auch verschiedene Aufgaben mit differenzierten Komplexitätsstufen hinzugefügt werden sollten. Zudem mangelt es an unterschiedlichen Stufen der Unterstützung, an Feedbackformaten und variantenreicher Darstellung des Lernstoffs. Eine Adaption an einzelne Lernausgangslagen ist nur durch Erstellung neuer Materialien möglich. Die Möglichkeit der Schüler:innen, Entscheidungen zu treffen, ist ebenso ausbaufähig wie die Steuerung und Kontrolle des eigenen Lernprozesses. Eine kritische Reflexion des Lernstoffs sollte ebenfalls durch die Lehrkräfte angeregt werden und auch die verschiedenen Lernhintergründe sollten stärkere Berücksichtigung finden.

Zudem sollte überprüft werden, welche Themen für die Grundschule relevant sind und ob es auf anderen OER-Plattformen Material gibt, welches sich auf gültige Quellen bezieht. Des Weiteren müssen die Lehrkräfte wichtige Elemente wie die aktive Entdeckung der Umwelt und den Vergleich von Symmetrien selbst bedenken und einbinden. Absichten und Einschränkungen hinsichtlich Inklusion werden durch das Materialpaket selbst bislang auch nicht aufgezeigt – ein weiterer Ansatzpunkt für eine kritische Revision.

5 Diskussion

Nachdem das Medienpaket im Verlauf der Arbeit analysiert wurde, werden im nächsten Schritt die erarbeiteten Chancen und Grenzen der Nutzung der Medien im inklusiven Mathematikunterricht vorgestellt. Anschließend wird diskutiert, inwieweit sich das Medienpaket für den Einsatz im inklusiven Mathematikunterricht eignet. Dabei werden insbesondere Verknüpfungen zu Müller (2016) hergestellt, der OER mit inklusivem Lehren und Lernen verbindet.

Für inklusiven Mathematikunterricht, in dem Lehr- und Lernmaterial eine zentrale Rolle zukommt, wird Material benötigt, welches die Diversität der Lerngruppe berücksichtigt, also optimalerweise inklusionssensibel und bestenfalls dazu qualitätsgeprüft ist (Vogt et al., 2021; Pieper et al., 2023). OER gelten als inklusionssensibel, wenn sie Inklusion ermöglichen, d. h. wenn auf die verschiedenen Charaktereigenschaften der Schüler:innen Rücksicht genommen und an die einzelnen Bedarfslagen angeknüpft wird, sodass alle im Unterricht am gemeinsamen Gegenstand lernen können (Vogt, 2022).

In diesem Zusammenhang ist festzuhalten, dass das im Rahmen dieser Studie untersuchte Materialpaket in verschiedenen Formaten verfügbar und in verschiedenen Sozialformen nutzbar ist. Dementsprechend kann an die einzelnen Bedarfslagen angeknüpft werden. Nicht zu vergessen sind jedoch die kritischen Aspekte. So fehlen etwa Aufgaben mit verschiedenen Komplexitätsstufen, unterschiedliche Stufen der Unterstützung und unterschiedliche Darstellungen des Lernstoffs. Darüber hinaus ist das Material nur in geringem Maß veränderbar und auch Absichten und Einschränkungen hinsichtlich Inklusion werden nicht genannt.

Weiter ist zu argumentieren, dass OER im Kontext von Inklusion die uneingeschränkte Möglichkeit bieten sollten, Lernmaterialien an individuelle Bedürfnisse anzupassen (Müller, 2016). Zwar kann das Material an verschiedene Sozialformen sowie physische und digitale Lernumgebungen angepasst werden, doch fällt insgesamt auf, dass es keine uneingeschränkte Möglichkeit der Anpassung bietet. Grund dafür ist, dass „[d]as Material und die Aufgaben […] vorgegeben [sind] und […] nicht individuell verändert werden [können]“ (L1). Material, das auf die einzelnen Schüler:innen zugeschnitten ist, muss daher von der

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Lehrenden neu erstellt werden. Lediglich mit dem vorhandenen Medienpaket zu unterrichten, hätte zur Folge, nicht auf individuelle Bedürfnisse einzugehen und somit nicht alle Schüler:innen produktiv am gleichen Lerngegenstand arbeiten lassen zu können.

Weitere Anforderungen, die das vorliegende Material erfüllen muss, damit es als inklusiv bewertet werden und als geeignet für den inklusiven Mathematikunterricht gelten kann, betont Müller (2016), der sich mit inklusiven OER und den Anforderungen an ebendiese auseinandersetzt. Er setzt voraus, dass inklusives Material barrierefrei sein, Leistungsdifferenzierung zulassen, Veränderungen in Form von Strukturierungen und Visualisierungen ermöglichen und gemeinsames Lernen in den Fokus stellen muss – Kriterien, die das hier untersuchte Materialpaket nicht vollumfänglich erfüllt. Es ist nicht barrierefrei, da beispielsweise die Aufgaben nur lesbar und nicht hörbar sind (S1). Darüber hinaus bietet das Material nur im geringen Maß Differenzierungsmöglichkeiten (S3). Da Material und Aufgaben vorgegeben und nicht veränderbar sind (L1), gibt es auch keine Möglichkeit, Veränderungen in Form von Strukturierungen und Visualisierungen vorzunehmen. Gemeinsames Lernen ist zwar teilweise in Gruppenarbeit möglich, „das Material ist [jedoch] eher auf Einzelarbeit ausgelegt“ (L1).

Die Aspekte, die für die Eignung des Materials sprechen, können die Aspekte, die dagegensprechen, nicht aufwiegen. In seiner jetzigen Form ist das Materialpaket für den inklusiven Mathematikunterricht in der Grundschule ungeeignet.

Stellt man die Reviews der einzelnen Personen in den Vordergrund, so wird allerdings auch sichtbar, dass unterschiedliche Meinungen zur Inklusionssensibilität des Medienpakets bestehen. Fünf der sechs Befragten vertreten die Ansicht, dass es nicht inklusiv ist. Eine Reviewerin gibt jedoch an, dass es durchaus inklusiv sei – und tatsächlich zeigen die in den Reviews aufgeführten Aspekte, dass das Medienpaket auch aus Sicht der anderen fünf Reviewer:innen die Inklusionsaspekte zumindest teilweise umsetzt. Die unterschiedliche Gesamtbewertung kommt vermutlich dadurch zustande, dass bei der Analyse unterschiedliche Medien des Medienpakets im Vordergrund standen oder einzelnen Aspekten unterschiedlich viel Bedeutung zugesprochen wurde. Die Einstufung eines Medienpaktes als (nicht) inklusiv scheint schlussendlich trotz vorgegebener Kriterien subjektiv zu sein.

Nachdem untersucht wurde, ob das Material inklusiv ist, sollten des Weiteren die Anforderungen für inklusive Lernprozesse thematisiert werden. Laut Müller (2016) „[führen] inklusiv gedachte OER […] nur dann zu inklusiven Lernprozessen, wenn ihr konkreter Einsatz vor Ort der jeweiligen Zielgruppe angemessen ist und ein Lernen durch Kooperation ermöglicht [wird]“ (S. 44). Die Diskussion zeigt insgesamt, dass durch das vorliegende Material kein inklusiver Lernprozess stattfinden kann, da Barrieren bezüglich der Anpassung des Materials bestehen und die Bearbeitung der Aufgaben in Kooperation eher selten möglich ist. Zum Abschluss dieses Meta-Reviews kann daher festgehalten werden, dass das Medienpaket nicht für den inklusiven Mathematikunterricht geeignet ist, da viele Inklusionsaspekte nicht umgesetzt sind.

6 Fazit

Die Forschungsfrage „*Inwiefern eignet sich das Medienpaket der Siemens Stiftung zum Thema Symmetrie für den inklusiven Mathematikunterricht?*“ kann auf Grundlage der Analyse und Diskussion folgendermaßen beantwortet werden: Das Medienpaket weist Potenzial auf, zeigt jedoch auch enorme Lücken und Verbesserungsbedarfe. Teils erfüllt es die Anforderungen der Inklusionssensibilität, etwa im Bereich „*Die Umgebung der Lernenden*“, in dem die Reviewer:innen nur wenig Verbesserungspotenzial sehen. Die anderen fünf Bereiche weisen hingegen deutliche Defizite auf. Das Medienpaket berücksichtigt z. B. nur in geringem Maß verschiedene Komplexitätsstufen und Stufen der Unterstützung.

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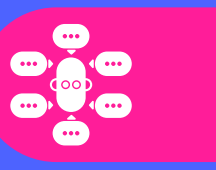

Darüber hinaus bietet es den Lernenden nur wenige Möglichkeiten zur Selbstbestimmung und eine geringe Zahl unterschiedlicher Darstellungen des Lernstoffs, die seine Anpassung an individuelle Lernprozesse einschränken. Außerdem gibt es keine Feedbackformate und die Schüler:innen werden nicht zur Reflexion angeregt.

Vor der Nutzung sind daher eine intensive Prüfung sowie eine didaktische Überarbeitung des Materials mit Blick auf die Schüler:innen empfehlenswert, die im konkreten Anwendungsfall damit arbeiten sollen. Ein besonderer Fokus sollte darauf gelegt werden, die relevanten Themen für die Grundschule auszuwählen, zu prüfen, ob es ähnliches Material mit gültigen Quellen gibt, und um welche Aspekte – beispielsweise die aktive Entdeckung der Umwelt – das Medienpaket ergänzt werden kann bzw. sollte. Um das Material an individuelle Lernausgangslagen anzupassen, muss jedoch neues Material erstellt werden. Hinzuzufügen ist außerdem, dass die unterschiedlichen Materialien des Medienpakets unterschiedliche Anforderungen der Inklusionssensibilität (nicht) erfüllen. Sie sind so unterschiedlich inklusionssensibel, dass sie nochmals einzeln anhand des FRoLLM-Worksheets intensiv analysiert werden sollten, um einen differenzierteren Eindruck von den Potenzialen und Lücken zu gewinnen, die es vor Einsatz des Materialpakets zu schließen gilt.

Fünf der sechs Befragten kommen zu dem Schluss, dass das Medienpaket nicht inklusiv ist. Eine Studentin findet es inklusiv. Hier zeigt sich, dass Lernmaterial-Evaluation trotz festgelegter Kriterien von Subjektivität geprägt ist. Auffällig ist zudem, dass einige Befragte gewisse Aspekte benennen, jedoch keine Bewertung zu diesen abgeben. Die Aspekte werden von den Befragten demnach als relevant beurteilt, doch eine klare Einschätzung bleibt aus. Auch dies unterstreicht, dass die Bewertung von Unterrichtsmaterial nicht allein auf objektiven Kriterien beruht, sondern durch individuelle Wahrnehmung und Bewertungssicherheit beeinflusst wird. Insgesamt ergibt die Diskussion, dass das Medienpaket in vorliegender Form nicht für den inklusiven Mathematikunterricht geeignet ist. Es bildet jedoch eine Grundlage, anhand der Material für inklusiven Unterricht erstellt werden kann.

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Magrid: A Meta-review of Learning Material Evaluations

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Abstract:

This meta-review explores the inclusion sensitivity of Magrid, a digital learning tool designed for children aged 3–9, with particular emphasis on learners with special educational needs (SEN). Three original reviews are synthesized: two by pre-service teachers in an international course held in Sweden, and one by a Czech PhD student within the field of education. All reviewers used the FroLLM framework, a reflective tool developed by an interdisciplinary European research team that offers six areas for reflection on inclusion sensitivity in learning materials. The meta-review shows opportunities for inclusion in terms of Magrid's adaptability, multilingual support, intuitive design, and accessibility. According to the original reviews, these aspects have the potential to contribute to highly inclusion-sensitive learning settings. Obstacles were connected to learners' limited opportunities to reflect independently, which hindered agency and empowerment, and to the way that feedback was directed towards the teacher instead of the students. The meta-review reflects on what different understandings of inclusion emerge in the reviews of Magrid. Against this backdrop, Magrid can be understood as supporting inclusion in terms of location and placement, providing SEN support as well as academic and social support for all learners. However, the more complex understanding of inclusion as community building and providing the learner with a feeling of belonging was less evident in the original reviews. The meta-review concludes that while Magrid offers strong structural inclusivity, deeper forms of inclusion—like student empowerment and belonging—are harder to achieve and evaluate through digital tools alone.

Keywords:

meta-review; Magrid; mathematics; inclusion; digital tool

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1 Introduction

Magrid is a digital teaching material with the full name *Magrid Learning Solution*. It is a digital learning tool that supports inclusive education by removing language barriers in early math. Magrid supports the development of mathematical, visual-spatial, and cognitive skills. It is designed for diverse classrooms, including students with special educational needs, speech or language difficulties, and multilingual backgrounds. The app uses visual, non-verbal instructions so all students can engage equally, regardless of their language skills. Through interactive exercises—such as sorting shapes or identifying patterns—students develop key skills in a playful and accessible way. Magrid promotes equity in learning by adapting to each child's individual pace and abilities. The material is directed to support learning in mathematics for younger school children and preschool children of about 3–9 years of age. There are also exercises available for students in the age group 9+. Magrid is presented as being especially directed towards special education needs (SEN) students. The number of exercises is large, about 2,500. Magrid has been designed, developed, validated, and tested in three countries: France, Germany, and Luxembourg. It was published with the copyright © *Magrid Learning Solutions Lucet, University of Luxembourg*. An interdisciplinary team of experts was involved in developing the material. These belong to the fields of education, psychology, neuroscience, cognitive science, and computer science. The material is available in seven languages: English, French, Luxembourgish, Portuguese, Spanish, German, and Nepali.

The following meta-review synthesizes three original reviews of Magrid. Two of the original reviews were performed in 2024 by two pre-service teachers attending a Blended Intensive Programme (BIP) in Örebro, Sweden. One of these pre-service teachers was Swedish and the other one Czech. The third review was performed during the spring of 2025 by a PhD student in the field of education from the Czech Republic. The same evaluation tool, FroLLM, was used by all three students. The FroLLM framework will be briefly explained in the methodology section. The context of the 2024 reviews was that they were performed in relation to a BIP course on inclusion and diversity, which had a special focus on digital teaching and learning materials. A BIP is an intensive, temporary, and hybrid course with its own curriculum. It is supported by the European Commission as part of the *Erasmus+* funding lines and as a group mobility activity for students and higher education teachers. To arrange a BIP, at least three institutions of higher education within the European Union must collaborate. The BIP at hand was a co-arrangement between Ostrava University, Bielefeld University; and Örebro University. In 2024, it was held in Sweden, at Örebro University; before that, it had already been carried out twice, in Ostrava and Bielefeld. During this BIP, students were introduced to the FroLLM framework as a tool for evaluating the inclusion sensitivity of teaching materials.

Consequently, the context of the original reviews and the knowledge, national setting, and understanding of inclusion might differ between the reviewers. However, conducting this kind of meta-review is still rewarding as it has the capacity to identify discrepancies as well as connections between what is considered to be inclusionary in the material at hand, or highlight diverse understandings of obstacles and opportunities for inclusive learning within the six FroLLM reflection areas. However, as all three reviewers approved of the FroLLM and reflected on the inclusion sensitivity in the material with the guidance of pre-determined questions, it is harder to evaluate how the FroLLM and the reviewers' skills and knowledge influenced their review of aspects that might support or disrupt inclusion. Therefore, a reflection is provided on the thematic synthesis of the original reviews, based on earlier research into the concept of inclusion. This reflection considers opportunities and obstacles in relation to different understandings of inclusion identified in earlier research (Nilholm & Göransson, 2014).

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2 The FroLLM framework for evaluating inclusion sensitivity

The FroLLM is one of the main outcomes of an *Erasmus+* project called *digiLLM*[1], in which the University of Luxembourg, Örebro University, Dalarna University, and Ostrava University participated. The project focused on teaching and learning materials and their inclusion sensitivity, especially regarding digital learning materials. Furthermore, the FroLLM was developed by a team of interdisciplinary researchers from the fields of inclusive science education, the history of education, inclusive mathematics education, and the field of teaching and learning materials. To briefly describe the FroLLM, it is a learning and evaluation tool geared towards inclusion sensitivity in digital learning materials. It contains six reflection areas that have been identified as carrying properties of special interest when it comes to focusing on learners and their need for support in their learning processes, thus leading to a material that is inclusion-sensitive. To each of these areas of reflection on inclusion sensitivity concerning the learner in relation to the material, there are educational questions that can guide the reflection. The reflection areas are Philosophy, Learners' Environment(s), Learners' Needs, Learners' Reflections on Learning, Learners' Agency, and Learning Feedback for Learners. It is always recommended and important to adapt the questions, supplement and examine them, in order for the FroLLM to work well for materials used in the educational system and context at hand.

The FroLLM builds on earlier research and evaluation tools or frameworks for teaching materials, such as the work of Mochizuki et al. (2019) on the Eight Affordances (8A) Model for teaching materials: Ubiquitous Learning, Active, Knowledge Making, Multimodal Learning, Recursive Feedback, Collaborative Intelligence, Differentiated Learning, Metacognition, and Accessibility. The six reflection areas in the FroLLM cover, among others, topics such as flexibility of use, the possible adaptation of the material or its modalities, students' motivation and concentration levels, and the availability of the teaching content. These areas have also been identified in earlier research on teachers' understanding of possibilities to foster literacy amongst students, as well-used and well-adapted digital teaching materials are used (Alsalem, 2016).

2.1 Inclusion Sensitivity in Learning Materials

For the purpose of this meta-review, I have adopted the same broad understanding of inclusion that was developed in the digiLLM project:

> [A] broad understanding of inclusion, taking all differences between people into consideration and aiming to dismantle barriers to education. Given the wide diversity of learners and their educational needs, we acknowledge that there is no "perfect inclusive" material. That is why we choose to talk about "inclusion-sensitive" materials[.] (digiLLM, n. d.)

Research tends to prioritize either inclusion or digitality and does not consider them simultaneously and equally. At times, digitality is depicted as something that contributes to modernization and automatically solves issues with inclusion (Ben-Yehudah et al., 2018). To provide the basis for a more nuanced discussion, and to perform the meta-review in a more structured manner, an overarching aim has been formulated for the following meta-review. This aim is to provide insight into obstacles and opportunities regarding different aspects of inclusion when using this specific learning material, Magrid. Consequently, the meta-review adds an understanding of inclusion to the thematic synthesis of the original reviews.

The need to reflect on different understandings of inclusion stems from the understanding of digital materials for learning (as well as analog ones) as framing

[1] This Erasmus+ cooperation partnership project has the ID 2022-1-DE01-KA220-HED-000086909.

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and creating inclusive teaching in close interaction with the teacher and the student, as being the third corner in a didactic triangle. In addition, this teaching is also impacted by the surrounding environment, school, society, time, and place (Wåger & Bagger, 2024). Consequently, an evaluation model, framework, or quality evaluation system can never on its own explain or foresee in what way the material may impact teaching and learning, and how and if it will prove genuinely inclusive for every student. How a material is used—by whom, for what, together with whom, and in which educational context—further impacts if and how the material can lead to sustainable, inclusive, and successful learning for every student. These circumstances, in terms of real opportunities to learn, are connected to both short- and long-term obstacles (Jacquet, 2016), and also to socio-economic aspects, marginalization, and segregation in school and society. As stated by Mochizuki et al. (2019): "Links between the quality of educational materials and learning outcomes are complex, and quality assurance mechanisms for educational resources—whether paper or digital—can only partially address pedagogical issues" (p. 46). Nevertheless, inclusion sensitivity is considered to be both a means and a goal on the way towards sustainable learning and high-quality education. Therefore, teaching materials are a central part in creating inclusive teaching, meaning a teaching culture and learning environment that support the diversity of students in their learning (Ambrose et al., 2010).

3 Methodology

This meta-review is a synthesis of the three original reviews, which have evaluated the inclusion sensitivity of Magrid by following the FroLLM. For the purpose of performing the meta-review, a thematic and qualitative content analysis was initially conducted following Braun and Clarke (2019, 2021). Obstacles and opportunities to inclusion are then discussed. Afterwards, the six reflection areas of the FroLLM are compared in terms of commonalities and discrepancies between the three reviews. Drawing on earlier research in the area, digital teaching and learning materials are considered to be part of the teaching content (Wåger & Bagger, 2024). At the same time, teaching and learning materials have the potential to disrupt the complex interactions between the teaching content, the teacher, and the students. Therefore, patterns within and across the identified themes and reflection areas are discussed in relation to three different conceptualizations of inclusion found in earlier research. These will be outlined in the following sections.

4 Results of the Thematic Analysis of Inclusion Sensitivity in Magrid

The analysis identified obstacles and opportunities to inclusion in general and across the six reflection areas. Inclusion is found to be broadly understood as sensitivity to learner diversity and a commitment to removing educational barriers, rather than achieving a perfect, one-size-fits-all solution. This is regardless of the reviewers' contexts or the setting in which the reviews were performed.

Obstacles and opportunities to inclusion across reviews and reflection areas

The reviewers commented on the many possibilities to adapt exercises and the use of the material as an important prerequisite for inclusion sensitivity. These adaptions concerned, for example, features, difficulty levels, sensory-friendly design, multilingual support, and the built-in approach or perspective of Universal Design for Learning (UDL). UDL refers to a teaching design that provides meaningful learning and access to the teaching for different kinds of learners (CAST, 2024).

> The website offers the accessibility menu with the ability to change the text size, use text spacing, pause animations, hide images, change line height

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> or use dyslexia-friendly function, make the cursor bigger or use reading mask or reading guide[.] (Reviewer 1)
>
> Children can learn independently, at their own pace, and pupils with special educational needs can catch up with their peers[.] (Reviewer 3)

In addition, the reviewers noted that the design and interface also support inclusiveness, since there are visual aids, possibilities to be guided, and interaction built into exercises. The adaptability, together with the design, thus provides a means to secure inclusion and the material was overall considered highly inclusion-sensitive by the reviewers:

> The subject content is available in language that the student can choose (see the language area in the introduction). The content is represented visually by showing what to do. It's interactive and available for students with specific needs[.] (Reviewer 2)

Even though the reviews were overall positive and showed that the reviewers were impressed by the opportunities to adapt the materials and the inclusion-sensitive interface and design, with cognitive load, auditive and visual stimulation being limited, they criticized the lack of possibilities for the learners to reflect and have agency in their learning processes. Much of the feedback was directed towards teachers or parents instead of the learners themselves. Even though the material is highly developed for SEN students and aims to support and prevent obstacles by its UDL approach, the reviewers found Magrid to lack an unambiguous definition of inclusion. My comment on this is that this could also mean that the reviewers themselves have different expectations of what inclusion really means.

Learners' Needs

Design and accessibility play an important role in how inclusion-sensitive the reviewers understand Magrid to be in relation to learners' needs. Before the student starts working with Magrid, they can choose a setting depending on diagnoses such as dyslexia or ADHD. The exercises will then be displayed differently depending on this choice. In sum, the reviewers considered Magrid's ability to adapt to different levels of knowledge and complexity, the different languages, and various options of adapting the user interface to different kinds of needs. Reviewer 1 describes their impression thus: "accessibility menu with the ability to change the text size, use text spacing, pause animations, hide images, change line height or use dyslexia-friendly function, make the cursor bigger or use reading mask or reading guide".

However, one of the reviewers criticized a lack of representativeness in terms of culture, meaning a lack of presence of different kinds of cultural expressions or illustrations in the exercises, and an overly strong focus on cognitive factors for learning only.

Learners' Environment

The reviewers evaluated Magrid's inclusion sensitivity in the reflection area Learners' Environment as satisfactory as Magrid allows for a diversity of learning scenarios. It is possible to use Magrid on different kinds of devices, online and offline: "yes this material can be used practically and digitally as a math learning solution process because this program doesn't need internet or WiFi" (Reviewer 2).

In addition, Magrid can be used in both individual and group settings and supports collaborative learning: "The app can also be used in a collaborative way. Small groups of 2-3 children can collaborate and discuss exercises on one device. It is also possible to create dedicated accounts for group work" (Reviewer 3).

One obstacle identified within this reflection area was that physical accessibility was not addressed, which might play a role in inclusion.

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Learning Feedback

Reviewers' notes were the most critical in this reflection area because a large part of the feedback provided by Magrid is directed towards teachers or parents: "I haven't seen any possibility for student to see and reflect his own learning process, the dashboard is available only for teacher after solving a simple math exercise" (Reviewer 1).

The reviewers also deemed the feedback to the learner as superficial, which limits learners' opportunities to self-regulate and track their learning processes. Dashboards for adults and motivational features like star systems are available. The reviewers also had different views on this, as one reviewer stated that the feedback to the learner was constructive and comprehensive whilst the others deemed it to be insufficient.

Learners' Reflection on Learning

The reviewers understood this reflection area as closely connected to the one on learning feedback. Opportunities that were mentioned in the reviews were connected to the support Magrid may offer to the development of cognitive skills: "The material includes visuospatial, geometrical, number-specific tasks in a visual format. It uses spaced repetition techniques and techniques that develop cognitive, visual and numerical skills. It includes multisensory tasks by adding audio and visual effects and interactive elements" (Reviewer 1).

Development of these skills will, in both a short-term and a long-term perspective, increase learners' opportunities to reflect on their own learning. Although this was not directly prompted in Magrid: "The program does not offer this" (Reviewer 3).

The elements mentioned by the reviewers as contributing to this cognitive development were multisensory tasks as well as visuospatial and repetitive techniques. A critique regarding this reflection area was that there was, as already indicated, no support for individuals' reflections and this can be especially challenging for students with intellectual disabilities.

Learners' Agency

The reviewers appreciate the inclusion sensitivity provided through various configurations and choices Magrid allows its users to make regarding different tasks. They also experienced Magrid's interface as overall intuitive. This supports learners' agency, as the student can work independently: "the learners can decide to choose their own exercises and they have the opportunities to develop and improve themselves by using the Magrid math application processes without help of their parents" (Reviewer 3).

However, there is no consensus among the reviewers on how much agency or control would be appropriate or even desirable. Therefore, the assessment of inclusion sensitivity regarding learners' agency remains ambiguous across the original reviews. This is also displayed clearly in the reviewers' overall emphasis on adults being those in charge of control and planning, as seen in previous reflection areas. Some of the reviewers note that this may undermine learners' independence and empowerment. My reflection on this circumstance is that it might mirror differences in the reviewers' own experiences of teaching and learning, students and their expectations regarding feedback to the learner and the need of learner's agency.

Philosophy

Two of the reviewers, Reviewer 1 and Reviewer 2, strongly agree in their understanding of Magrid as being highly evidence-based and clear in its design: "The material is structured logically and comprehensible. It's easy to understand, it's explained what and how to do the exercises, it includes the navigation elements and graphic markers" (Reviewer 1).

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Furthermore, reviews 1 and 2 state that Magrid provides indications of alignment with a curriculum, explaining its foundations and perspectives: "Yes, Magrid is scientifically explained and regarded in their exercises" (Reviewer 2).The third review does not concur with this evaluation.

All three reviews state that Magrid provides a clear statement concerning its goal of contributing to inclusive education. This was found both in the Magrid product information and in the descriptions regarding its profile. Obstacles that the reviewers identify regarding inclusion sensitivity connected to the reflection area of philosophy stem from a lack of critical reflection and transparency regarding limitations in the app and how it can be used.

5 Discussion and Key Insights

In the following section, a comparison will be made between understandings of inclusion that are commonly advocated and used in earlier research, drawing on the work of Göransson and Nilholm (2014). Four such understandings have been identified, which range from placement of students with disabilities in mainstream classrooms to community building approaches for all students. They can be described as four categories of inclusion:

1) Spatiality or placement for students with disabilities in mainstream schools
2) Category 1 + social and academic needs of students with special educational needs (SEN). Inclusion here goes beyond access to the spatial rooms or placement. It is also directed towards specific pedagogical and social support tailored to the needs of SEN students.
3) Category 2 + social and academic needs of every student. In this category of understanding, inclusion extends to all learners, regardless of ability, ensuring that all students are provided both support and challenge.
4) Category 3 + participation in communities and a sense of belonging for every student. This category stretches beyond the social dimension of learning in a class or academic setting. It also concerns the students' current and future opportunities to be involved in learning communities, take part in meaningful relationships and experience a sense of belonging.

In sum, the first three categories could be said to be fulfilled by Magrid in a satisfactory manner, according to the reviews. The fourth, though, was harder to discern for certain review.

Concerning inclusion in the first category, the reviewers pointed out that Magrid made sure that all students could have access to the same digital learning environments, regardless of disabilities. This can be understood as a spatial/placement issue of inclusion. In the app, this is realized by—for example—providing all students access through various devices and even offline. Additionally, they can be placed at an appropriate level of difficulty. The second category of inclusion, which focuses on the social and academic needs of SEN students, appeared in the reviews via the adaptations to the exercises (e.g., dyslexia-friendly mode, visual aids) that allow Magrid users to address special needs. The interface itself was also understood by the reviewers as designed in a manner that is sensitive towards some disabilities, for example autism and dyscalculia. Finally, Magrid offers scaffolding systems and teacher or parent dashboards to monitor progress, which may help teachers tailor individual learning paths for their students. Through these adaptions and the interface, students can collaborate or work in parallel with peers, but on their own terms. This could potentially satisfy both social and academic needs of SEN students. A reflection on the third category, in which all students are supposed to be supported, can be found in the reviewers' notes as well. They mention that multiple support structures are present in Magrid, e.g., in its flexibility and interface, or via the adaptions for which the app allows.

The fourth category of inclusion aims at community building and at students feeling that they belong to a community. Ideas on how Magrid could provide this community were less easily distinguished across reviews. Magrid puts more emphasis on individual development and learning but also supports some collaboration: group work, teachers sharing what they learn about students, and shared exercises amongst students may indicate opportunities for community building. However, as the reviewers are not satisfied with students' self-reflection, agency, autonomy, and active participation in the learning process, this category of inclusion cannot be fully secured. Also, since belonging to a community is a highly individual experience, it is not possible to evaluate it in an objective way.

The meta-review therefore implies that the higher-level and more complex aspects of inclusion might be hard to grasp with an evaluation tool, but also with a solely digital tool for learning, such as Magrid.

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Biology in Context. Meta-review of Learning Material Evaluations

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Abstract:

Biology is a progressive field that is dynamically developing and educational resources should be adapted to this. This paper presents the results of a meta-review summarizing the findings of five independent evaluations of the textbook “Biology in Context” (Šíma, 2024), a new addition to the Czech educational resource market. The aim of the meta-review is to identify and assess the inclusive elements contained in the textbook based on the detailed framework of the FRoLLM criteria. We are interested not only in content aspects, but also in the didactic sequences of the educational text regarding diversity and inclusion of students, as these can affect learning outcomes as well. The results indicate that, while the textbook has an attractive design and is user-friendly, its inclusive potential is limited. It does not include elements of reflection or self-reflection for students. Although the textbook offers various learning tasks, it primarily targets lower or intermediate levels of thinking and creativity. The textbook does not provide students with feedback on their learning progress and lacks scaffolding strategies. However, the textbook stands out for its clear and logical structure at both macro and micro levels. Different font styles and icons make it easy to navigate the material. Inclusive elements can be found in the components of the diverse presentation of the curriculum (visuals, pictures, graphs, links to videos and audio sequences) and in the development of literacy. Another positive aspect is the availability of a digital version of the textbook.

Keywords:

meta-review; textbook analysis; inclusion; learning materials; biology

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1 Introduction

The Czech education system places a strong emphasis on students' integration into the educational process. Working with a diverse classroom is a significant challenge in the pre-service training of future teachers at universities, but the topic is also a key concern for practicing educators. However, many teachers still tend to reduce the concept of inclusion to special education, focusing on meeting the needs of students with specific educational requirements or, in the context of migration, the intercultural aspects of the learning environment. Given the importance of inclusion in schools and the goals of inclusive education, it is also necessary to examine how textbooks and other educational materials address this issue. Textbooks (as well as curricula) should appropriately reflect the reality of a heterogeneous classroom.

While the Ministry of Education codifies equal access to student education in strategic documents and promotes inclusive approaches to learning (and teaching) through various tools, textbook analyses focused on inclusion are not carried out in our country. Detailed research on teaching resources in terms of inclusive elements in science textbooks is not systematically carried out abroad either. Existing international studies focus primarily on the field of social sciences. An analysis of international textbook studies with an emphasis on cultural, religious, and national diversity was conducted by Niehaus (2018), who states that "social diversity is still perceived as a challenge to social cohesion and portrayed as something problematic, carrying a certain conflict potential" (p. 329). Another important source is the UNESCO report "Making Textbook Content inclusive: A Focus on Religion, Gender, and Culture" (2020), which analyzed civic education textbooks used in over 28 countries. The report emphasizes that social diversity is increasingly being taken into account and that the analyzed textbooks "are characterized by an increased critical reflection on societal discrimination against various groups and ultimately by a significant trend towards a more prominent consideration and representation of various social groups and minorities" (p. 2).

In the area of identifying inclusive elements in biology textbooks, which was the focus of our meta-review, a qualitative study by Rechenberg (2017) is particularly noteworthy. She examined a sample of 30 Swedish biology, history, civics, and religion textbooks to see whether they depicted people with disabilities, of different ethnic backgrounds, and of different ages as actively involved in everyday life ("participating"). She found that less than half of the textbooks analyzed depicted people with disabilities as active participants, and the representation of inclusion was even worse when it came to people with disabilities who were of different ethnic backgrounds and/or older.

Inclusive education is becoming the norm, not the exception—schools routinely accept students with a variety of specific needs and educational backgrounds. Teachers are therefore already facing the challenge of inclusive teaching, but they often still lack appropriate tools and materials to do so. Inclusion, as we define it for this article, is about ensuring quality education for all students, regardless of their abilities, disabilities, or cultural differences. Inclusion does not just mean having students with special needs in the classroom: it is a principle that must also be present in teaching materials. However, teaching resources used in Czech schools often do not yet meet this requirement.

The biology textbook "Biology in Context" (Šíma, 2024) was selected for the meta-review focusing on inclusive elements for several reasons. It represents a modern educational resource that has recently been introduced into the teaching of students in lower secondary schools and grammar schools in the Czech Republic. Its content is in line with the so-called Framework Educational Program (Rámcový vzdělávací program, short: RVP) for grammar schools in the field of natural sciences, especially in the subject of Biology. The RVP contains mandatory curricular guidelines created by the Ministry of Education, Youth

and Sports of the Czech Republic. Most textbook authors try to adhere to the topics described in it, as well as the competencies that students are expected to develop according to the RVP, and the expected learning outcomes. Another reason for selecting the textbook was its novelty (2024) and also the possible integration of interdisciplinary connections, which—according to the RVP—are meant to be created by the interconnection of individual subjects.

The findings of the meta-review can guide science teachers in selecting teaching materials for students. At the same time, the results can provide feedback to textbook authors and publishers, which will contribute to improving the quality of educational materials.

2 Methodology

The main research question in creating the meta-review of the textbook was: *What types of inclusive elements are included in this biology textbook, and how are these elements presented by the textbook for the students studying with it?* The aim of the meta-review was to compare the five partial analyses, each of which focused exclusively on the inclusive aspects of the biology textbook, and create a synthesis of its attributes in relation to the inclusive elements of the learning materials' content. In this article, we consider the meta-review to be a "review of reviews" (Hunt et al., 2018), a systematic and transparent processing of existing studies that offers a comprehensive view of a specific topic. It is a form of knowledge synthesis that aims to gather existing evidence from various thematic reviews in a given field and focus on the common features and differences between the sub-reviews (Ridley, 2012). The concept of inclusion in learning materials is understood more broadly. It does not only refer to how materials are adapted to students with specific learning needs but also includes the ways in which materials are adapted to the diverse needs of all students, i.e., students with different learning styles, scaffolding needs, levels of engagement, previous experiences, ways of receiving feedback and self-reflection, etc.

The meta-review of the textbook "Biology in Context" (Šíma, 2024) is based on a comparison between five independent analyses of this textbook, which were created in November 2024 by students enrolled in teacher training programs at the Faculty of Education at the University of Ostrava. The reviewers were trained by a specialist teacher at their university in the use of the Framework for Reflecting on Living Learning Materials (FroLLM) for didactic analysis of educational texts, which was developed as part of the digiLLM project to support the creation of inclusive educational materials (see below). Before this biology textbook was analyzed, a pilot study was conducted. The reviewers analyzed one chapter from another science textbook using the FroLLM framework in order to better understand the characteristics of inclusive elements that might be incorporated into a textbook. The text analysis focused on how the textbook reflects students' needs, individualized learning, how students can reflect on their learning strategies, and what the philosophical background of the textbook is. The aim was to refine the concept of inclusive elements in the text and create a method of textbook analysis for further application of the FroLLM framework that the reviewers could then use on "Biology in Context".

The analyses were conducted based on the six predefined areas and thematic frameworks of FRoLLM: (1) Philosophy and Design of the Material, (2) Learners' Needs, (3) Learners' Environment, (4) Learning Feedback for Learners, (5) Learners' Reflections on Learning, (6) Learners' Agency. For each of these frameworks, the FroLLM provides specific preformulated questions to further characterize the areas. Indicators are also defined for each of the domains.

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3 Analysis and Synthesis

The methodological concept of the "Biology in Context" textbook differs from previously used traditional and extensive biology textbooks for grammar schools. It is based on the principles of modern teaching and an activating design for educational materials. The first evaluated area was **the Philosophy and Design of the material**.

3.1 Area 1: Philosophy and Design of the Material

In analyzing the biology textbook, we questioned whether the material **provides explanations regarding its structure, selection, and design**. This included examining how the textbook is structured both at macro and micro levels. The macro level of a textbook refers to its overall structure—how chapters and topics are sequenced, how the content aligns with curricular goals, and how navigation is supported through elements like overviews or contents pages. The micro level concerns the internal structure of individual pages or sections—such as layout, typographic cues, symbols, and how learning tasks are locally organized. In our meta-review, "Biology in Context" was found to be clearly structured at both levels, aiding user orientation and coherence. The introduction presents an overview of all topics along with a set of specific icons that appear throughout the text, referencing their meanings. The reviewers agreed that this approach supports easy navigation and understanding of the material's structure.

The textbook is designed as a comprehensive guide to lessons, allowing its use for entire classes, group work, or individual study. Although the author recommends systematically progressing through the material, selected sections can be used independently depending on lesson objectives, students' needs, or targeted competencies. The textbook is intended for multi-year secondary schools and elementary schools, but the grade level is not clearly specified.

Further examination in the reviews focused on **inclusive elements within the textbook**. The preface states that the textbook is designed with contemporary requirements for the development of competencies and literacy in mind, including digital literacy, and that it is tailored to the mindset of today's higher secondary school students. However, all five reviewers noted that explicit mentions of inclusion are absent. While the textbook incorporates diverse learning tasks with varying cognitive demands, it does not explicitly aim at inclusion.

Four out of five reviewers appreciated that the textbook follows a **logical structure** with interconnected chapters. Different graphic elements, such as colors and fonts, distinguish key information. For instance, primary topics are highlighted in blue, while supplementary information is underlined in brown. This system aids students in identifying essential content and navigating the text efficiently.

The evaluated textbook was also analyzed in terms of content **reliability**. It includes a list of reviewers, most of whom are university-educated experts in the field of natural sciences, ensuring content accuracy and reliability. In the Czech Republic, textbook evaluation typically involves a rigorous review process to prevent misinformation or linguistic inaccuracies (cf. Martínková, 2007; Zounek & Tůma, 2014). There is no specific directive for evaluating biology textbooks in the Czech Republic, but there is a set of regulations and criteria according to which the Ministry of Education, Youth and Sports evaluates materials, including biology. Textbooks must undergo a review process in which experts evaluate their quality. The Ministry of Education, Youth and Sports may exclude certain criteria, but the main criteria —i.e., the RVP, the books' content, and form—remain. In the Czech Republic, there are so-called pedagogical-research resources describing grids, detailed evaluation checklists focused on didactics and textbook structure, development of key competencies of students, comprehensibility of text, suitability of exercises and images for teaching.

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Furthermore, the textbook also provides references to websites as well as additional text-based and digital sources that offer more detailed information on key topics. In the preface, the author emphasizes **the relevance of the topics** and their presentation, highlighting the current requirements for developing students' competencies and literacy. However, explicit references to the Framework Educational Program (RVP) and **research findings** are absent.

When evaluating the **Philosophy and Design** of the instructional material, the five reviewers agreed that the textbook provides not only theoretical knowledge but also practical insights applicable to real-life situations, which is valuable for student learning. They highlighted the clarity of topic organization and the relevant selection of content in accordance with the Framework Educational Program for high schools. However, the textbook does not explicitly include elements of inclusion or direct differentiation in teaching.

One reviewer positively assessed the detailed explanation of the material's philosophy and concept, including the theoretical foundations of biology instruction and its focus on the target student groups. We appreciate the logical structure of the content, clarity of presentation, and quality of design. All reviewers confirmed that the textbook references reliable and verifiable sources. They regard it as a well-structured educational resource that provides relevant information.

3.2 Area 2: Learners' Needs

Another area analyzed by the reviewers was the textbook's way of **meeting students' needs**. The reviewers examined whether the textbook offers various learning approaches or tasks at different levels of complexity for the same topic. It was found that the textbook does **not provide much diversity in learning tasks**, at least not within the same topic. At the end of each chapter, there are exercises, but they are not differentiated according to difficulty. They are mostly at the level of simple thought operations or cognition exercises, with the answers to the questions easily found in the explanatory text. The textbook does, however, include references to websites and videos that can provide additional information for interested students and expand their knowledge.

A specific criterion for the reviews were the support strategies that facilitate student learning, known as scaffolding. Despite scaffolding being explicitly mentioned in the textbook itself (Šíma, 2024), all reviewers noted a lack of step-by-step problem solving, guiding questions, and hints. Three reviewers pointed out that there is no embedded guidance or modeling of task assignments, leaving the teacher responsible for supporting students through various learning difficulties.

All reviewers positively evaluated the textbooks' use of various **forms of content representation**, such as text, images, graphs, and video links. These elements help adapt teaching concepts to students' motivation and needs by supporting visual and auditory learning styles. However, the reviewers also noted that the textbook does not provide a structured and transparent scaffolding approach. Three of them agreed that the printed version of the textbook cannot be tailored to individual students' needs. The online version offers some flexibility, such as adjusting the learning pace, but the overall design of the material remains unchanged.

3.3 Area 3: Learners' Environment

The learning material was also examined in terms of suitability for different forms of classroom organization and **learning environments**. The five reviewers found that the material is appropriate for various instructional approaches, including teacher-centric lessons, group work, and independent study. Teachers can use the textbook flexibly as a resource for different activities, but only based on their preferences and individual teaching approaches. The textbook does not differentiate tasks according to whether they

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should be completed individually, in pairs, or in groups.

The textbook is usable in digital and physical environments. It is available in both print and electronic versions, with the latter accessible via an activation code included in the printed book. This allows the material to be used in **various learning settings**, including online education. Both versions of the textbook must be purchased by the students' parents, as higher secondary schools and grammar schools in the Czech Republic do not receive state funding for textbooks.

The reviewers agreed that both textbook formats (printed and digital) are designed for use in diverse educational environments. One reviewer, however, highlighted the time-limited validity of the QR and activation codes for the electronic textbook, making the printed version more accessible since it can be shared among students over a longer period of time. Another reviewer emphasized the advantage of the electronic textbook, which can be updated more frequently.

3.4 Area 4: Learning Feedback for Learners

A key parameter of the textbook is its potential to provide feedback, yet "Biology in Context" **does not offer various forms of feedback**. It only includes traditional exercises with answers that students can find directly in the text. There are no rubrics or assessment criteria to guide students in self-evaluation or peer feedback. They do not have access to solved tasks or sample tests, **limiting their ability to reflect on their learning progress**. While exercises with answers are present, the textbook lacks opportunities for deeper reflection and self-assessment.

The reviewers agreed that despite its initial appeal, the textbook does not provide mechanisms for learning reflection or self-evaluation. One reviewer even noted that while the material offers original knowledge practice, it does not include constructivist elements of feedback or self-reflective learning. There are no solutions or suggested steps for completing tasks.

3.5 Area 5: Learners' Reflections on Learning

The textbook does not focus **on explaining different learning strategies or techniques**. It primarily delivers factual information and practical experiments but does not provide differentiated approaches to learning. Although the textbook is visually appealing at first glance, its content does not motivate students to reflect on their learning processes. There are no tasks requiring students to describe or assess their thought processes.

All the reviewers agreed that the textbook offers limited opportunities for students to reflect on their learning. One reviewer pointed out that the material does not suggest different learning strategies and only provides minimal motivation for reflection. Another reviewer noted that the textbook emphasizes facts and the exposition of biological concepts or phenomena but lacks strategies to enhance independent learning. A third reviewer concurred regarding the low motivational potential of the textbook but evaluated its suggestions for laboratory experiments positively.

3.6 Area 6: Learners' Agency

All five reviewers agreed that the textbook offers few **opportunities for students to make decisions about their learning**. The material is structured in a fixed manner, aligning with the educational objectives outlined in the Framework Educational Program (RVP). Students can only decide whether to use additional video links and online resources. The textbook therefore **does not foster students' confidence in their ability to direct their own learning processes**. Tasks are designed with specific learning outcomes in mind, leaving little room for creative engagement—with the notable exception of laboratory exercises.

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Overall, **it does not encourage students to critically reflect** on the content or the learning material itself. There are no tasks or activities prompting them to think more deeply about the subject matter or the educational material. The approach to learning is primarily based on surface-level memorization rather than critical analysis or reflection.

All reviews agreed that the textbook offers limited opportunities for students to actively control their learning. The textbook does not provide students with the chance to make independent decisions about their education. However, in some sections, it does reference topic-related videos or websites that could support personal development.

4 Discussion and Conclusion

This meta-review presented a specific tool that can be used to evaluate inclusive elements in textbooks: the FroLLM framework. Based on five reviews of a biology textbook, it created a synthesis of findings on how the textbook "Biology in Context" enables students to understand the content, increase their motivation to learn, and regulate their own learning processes.

"Biology in Context" is a new educational resource in the field of natural sciences. It features an attractive design, incorporates numerous visual elements, and—unlike many textbooks in this domain—is also available in an electronic format. With a total of 304 pages and 120 two-page chapters, the textbook is not overly extensive or overloaded with facts, and overall, it is designed to be user-friendly. The five preservice teachers who used the FroLLM to review the textbook agreed that one of its main strengths is its clear and logical structure at both macro and micro level. They positively evaluated the use of icons, symbols, and different fonts, which help students guide their learning and emphasize important explanatory parts or concepts within the book. Furthermore, the reviewers appreciated that the textbook can be used in a variety of educational settings. However, they also pointed out some limitations regarding the fact that neither the physical book nor the e-book are available for free.

All reviewers agreed that the textbook provides minimal opportunities for students to reflect on their learning, offers insufficient feedback on learning strategies, and lacks scaffolding techniques. One reviewer noted the textbook's minimal motivation for reflection, three criticized the insufficient modeling of learning tasks. While the content effectively explains key concepts, facts, and processes, it places little emphasis on practice or adapting different learning strategies. However, the material has inclusive potential in specific areas that can be developed by the teachers using it in class. The strengths of the textbook in the area of inclusion, according to the reviewers, are:

1. **Various forms of content representation.** The textbook includes not only textual content but also numerous visuals, such as images, graphs, and links to videos. These elements help adapt teaching concepts to students' diverse learning needs, as they support both visual and auditory learning styles.
2. **Accessibility of the digital version.** The digital version of the textbook offers greater flexibility, by allowing teachers and students to adjust the learning pace, which can be beneficial for students with varying learning needs.
3. **Content and design.** The textbook is designed with current educational requirements in mind, emphasizing the development of essential competencies and literacies, including digital literacy. It is also adapted to the learning styles of today's lower and upper secondary schools in the Czech Republic, where the concept of constructivist teaching is very popular.

The five sub-reviews used for the meta-review produced similar findings. One reason for this may have been the primary piloting of the analysis tool, which

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was applied to a different textbook and subsequently discussed to ensure that all reviewers followed a similar procedure, and to clarify the observed criteria regarding the elements included in the text. Another reason could be the detailed structure of the FroLLM analysis tool, which is an effective guide used for working with educational resources. In fact, it explains in detail the criteria and indicators for inclusive components in the text and visual segments of learning materials, which can help reviewers find common ground in their perception and description of the phenomena under study.

An inclusive approach is now considered a fundamental principle of modern education. The meta-review is important in that it reveals the strengths and weaknesses of the teaching text and allows teachers and textbook authors to specify strategies that lead to the development of the potential of individual students.

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Das interaktive Tafelbild „Wie die Welt zusammenwächst“ – Ein Meta-Review

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Abstract:

In current educational discourse, digital teaching and learning materials, especially Open Educational Resources (OER), are often presented as having great potential for inclusive education (Müller, 2016; Pieper, 2024; UNESCO, 2017). This meta-review analyzes and discusses a freely accessible interactive whiteboard display provided by the Siemens Stiftung (2016). The learning material is called “How the World is Growing Together” (“Wie die Welt zusammenwächst”) and meant to be used for science lessons in elementary schools. The meta-review is based on four reviews that were written by pre-service teachers using the “Framework for the Reflection on Living Learning Materials” (FRoLLM) (Pieper, 2024) during the winter semester of 2024/25. The meta-review shows that the interactive whiteboard display is rated as well-structured and didactically useful, but that both its theoretical foundation and its inclusion sensitivity could be improved significantly.

Keywords:

meta-review; FRoLLM; inclusive teaching and learning materials; globalization; interactive whiteboard display

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Das interaktive Tafelbild „Wie die Welt zusammenwächst“ – Ein Meta-Review

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Zusammenfassung:

In aktuellen bildungswissenschaftlichen Debatten wird digitalen Lehr- und Lernmaterialien, insbesondere Open Educational Resources (OER), ein großes Potenzial für die inklusive Bildung zugeschrieben (Müller, 2016; Pieper, 2024; UNESCO, 2017). Der vorliegende Meta-Review analysiert und diskutiert daher das von der Siemens Stiftung (2016) bereitgestellte frei zugängliche interaktive Tafelbild „Wie die Welt zusammenwächst“ für den Sachunterricht in der Grundschule. Grundlage für den Meta-Review sind vier schriftliche Reviews, die von Lehramtsstudierenden mit dem „Framework for the Reflection on Living Learning Materials“, kurz „FRoLLM“ (Pieper, 2024), im Wintersemester 2024/25 angefertigt wurden. Die Ergebnisse des Meta-Reviews zeigen, dass das interaktive Tafelbild zwar als gut strukturiert und didaktisch sinnvoll bewertet wurde, die theoretische Fundierung und auch die Berücksichtigung inklusionssensibler Indikatoren aber noch deutliches Ausbaupotenzial aufweist.

Stichwörter:

Meta-Review, FRoLLM, inklusive Lehr-Lern-Materialien, Globalisierung, interaktives Tafelbild

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1 Einleitung

Mit der Ratifizierung der UN-Behindertenrechtskonvention im Jahr 2009 durch die deutsche Bundesregierung verpflichtet sich die Bundesrepublik dazu, ein inklusives Bildungssystem auf allen Ebenen umzusetzen (Beauftragter der Bundesregierung für die Belange von Menschen mit Behinderungen, 2018, S. 2). Hieraus ergibt sich die Notwendigkeit, allen Schüler:innen differenzierte Entwicklungsangebote bereitzustellen (Müller, 2021). Lehr- und Lernmaterialien nehmen dabei als „zentraler Bestandteil jeder pädagogischen Interaktion, jedes Lehrens und Lernens“ (Pieper, 2024) eine elementare Rolle ein. In der einschlägigen Literatur werden insbesondere digitalen Lehr- und Lernmaterialien und sogenannten Open Educational Resources (OER) große Potenziale zugeschrieben, wenn es darum geht, der starken Heterogenität der Lernenden gerecht zu werden (Deutsche UNESCO-Kommission, 2015; Fahrer, o. J.; Müller, 2016, 2021; Pieper, 2024; UNESCO, 2017). Ausgehend von dieser Annahme stellen sich die Fragen, was Lernmaterialien inklusiv macht und wie die Inklusionssensibilität von Materialien bewertet werden kann. Diese und weitere Fragen werden im Projekt „Digital Living Learning Materials“ – kurz: digiLLM – bearbeitet (digiLLM, o. J. a, o. J. b). Im Rahmen des Projekts wurde mit dem „Framework for the Reflection on Living Learning Materials” (FRoLLM) ein Instrument geschaffen, das es ermöglicht, Bildungsmaterialien mit Hilfe von sechs Kategorien hinsichtlich ihrer Inklusionssensibilität zu beurteilen (Pieper, 2024).

Der folgende Meta-Review basiert auf schriftlichen Reflexionen zu einem frei verfügbaren Materialpaket zum Thema Globalisierung, die von vier weiblichen Lehramtsstudierenden der Universität Bielefeld mit Hilfe des FRoLLM erstellt wurden. Das Materialpaket, ein interaktives Tafelbild mit dem Titel „Wie die Welt zusammenwächst“, wird von der Siemens Stiftung (2016) als OER für den Sachkundeunterricht an Grundschulen bereitgestellt. Die vier Reviews sind auf der Webseite des Projekts digiLLM (o. J. c) zu finden. Alle vier Studentinnen sind zum Zeitpunkt der Manuskriptlegung für diesen Beitrag im ersten Semester des Masterstudiengangs *Erziehungswissenschaft Integrierte Sonderpädagogik* mit dem Berufsziel Lehramt für sonderpädagogische Förderung eingeschrieben.

2 Materialvorstellung

Bei den Lernmaterialien, um die es im Folgenden gehen wird, handelt es sich um ein deutschsprachiges Medienpaket, das auf dem Medienportal der Siemens Stiftung frei verfügbar ist (Siemens Stiftung, 2016). Die Siemens Stiftung wurde 2008 gegründet und wird auf ihrer offiziellen Webseite als „unabhängige und gemeinnützige Organisation“ (Siemens Stiftung, 2025b) beschrieben, die von der Siemens AG gegründet wurde. Im Medienportal der Stiftung, dem auch das vorliegende Materialpaket entnommen wurde, werden digitale Unterrichtsmaterialien für den MINT-Unterricht von Klassenstufe 1 bis einschließlich 13 kostenlos zur Verfügung gestellt (Siemens Stiftung, 2025a). Damit handelt es sich bei der Siemens Stiftung um eine der vielen „Stiftungen, die den Zugang zu Bildung verbreitern möchten“ (Kerres, 2019, S. 8) und daher in der Produktion von Bildungsressourcen aktiv sind.

Das Materialpaket „Wie die Welt zusammenwächst“ behandelt das Thema Globalisierung und ist für den Sachunterricht der Grundschule konzipiert. Als Zielgruppe werden die erste bis vierte Klasse angegeben. Das interaktive Tafelbild beinhaltet insgesamt 27 Einzelmedien, darunter (interaktive) Übungen, Bilder, Grafiken sowie Arbeitsblätter und Handreichungen für die Lehrkraft. Die Medien sind zum einen in das Tafelbild integriert und zum anderen als Einzelmedien verfügbar. So können sie sowohl einzeln als auch kombiniert in einer Vielzahl von Konstellationen genutzt werden. Der Großteil der Einzelmedien wurde 2016 veröffentlicht und im Jahr 2017 sowie 2021 zuletzt aktualisiert. Je nach Medium stehen diese im JPG-Format, als HTML- sowie als PDF-, DOC-

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oder DOCX-Datei zum Download zur Verfügung. Alle Medien des Materialpakets stehen unter einer „CC BY-SA 4.0 International“-Lizenz. Das bedeutet, dass das Material verändert, weltweit verbreitet und neu zusammengestellt werden darf. Voraussetzung dafür ist, dass die Namen der Rechteinhaber:innen angegeben und Veränderungen benannt werden. Außerdem muss das neu bearbeitete Medium unter den gleichen Bedingungen weitergeben werden wie die ursprüngliche OER (Siemens Stiftung, 2016).

3 Methodisches Vorgehen

Um auf Grundlage der vier schriftlichen Reviews einen Meta-Review anfertigen zu können, wurden prägnante inhaltliche Gemeinsamkeiten sowie Unterschiede herausgearbeitet. Für diesen umfangreichen inhaltlichen Vergleich wurden die qualitativen Daten der Reviews zunächst mit Hilfe interpretativer und kategorienbildender Verfahren ausgewertet (Kelle et al., 2017). Analyserahmen und Auswertungsmethode für den inhaltlichen Vergleich sind dabei angelehnt an die inhaltlich strukturierende qualitative Inhaltsanalyse nach Kuckartz und Rädiker (2022). Bei dieser Methode wird „das Material typischerweise in mehreren Codierdurchläufen mit deduktiv und/oder induktiv gebildeten Kategorien codiert“ (Kuckartz & Rädiker, 2022, S. 104). Kuckartz und Rädiker gliedern den Prozess der inhaltlich strukturierenden qualitativen Inhaltsanalyse in sieben Phasen. Diese sind allerdings nicht scharf voneinander getrennt, sondern gehen ineinander über und können auch mehrfach durchlaufen werden (Kuckartz & Rädiker, 2022, S. 132). Für den vorliegenden Meta-Review konnten aufgrund des begrenzten Umfangs des daraus resultierenden Artikels nicht alle sieben Phasen vollumfänglich bearbeitet werden. Daher wurden in Anlehnung an Kuckartz und Rädiker (2022) die im Nachfolgenden beschriebenen vier Schritte durchlaufen.

In einem ersten Schritt wurden Hauptkategorien entwickelt. Diese lassen sich nach Kuckartz und Rädiker (2022, S. 133) oft deduktiv aus den Themen ableiten, die bereits bei der Erhebung der Daten leitend waren – so auch bei diesem Meta-Review. Aus den sechs genannten Themenbereichen und den beiden Abschlussbewertungen zum Material hinsichtlich der Inklusionssensibilität und OER wurden deduktiv acht Hauptkategorien gebildet und mit jeweils einem Großbuchstaben von A bis H gekennzeichnet (Tabelle 1).

Tabelle 1: Kategoriensystem für die qualitative Inhaltsanalyse

Kategorie		Subkategorie	Kürzel	Definition
A	Philosophie	Materialaufbau	A1	transparenter Aufbau der Materialien
		Materialauswahl	A2	Auswahl der enthaltenen Materialien
		Materialgestaltung	A3	Gestaltung der Materialien
		Materialverwendung	A4	Material gibt Hinweise auf die Verwendung und Anwendung der Materialien im Schulunterricht
		Inklusionsaspekt	A5	Absichten und Einschränkungen des Materials hinsichtlich Inklusion
		Bezug zum Lehrplan	A6	Bezug zu Anforderungen des Lehrplans
		Verwendete Quellen	A7	Bezug des Materialinhalts auf gültige Quellen
		Theoretische Hintergründe	A8	Erläuterung theoretischer Hintergründe

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Kategorie		Subkategorie	Kürzel	Definition
B	Bedürfnisse der Lernenden	Verschiedene Komplexitätsgrade	B1	Material enthält verschiedene Aufgaben für den gleichen Stoff in unterschiedlicher Komplexität
		Scaffolding	B2	Material bietet unterschiedliche Stufen der Unterstützung
		UDL	B3	Material beinhaltet verschiedene Arten der Darstellung des Lernstoffs, die an die unterschiedlichen Bedürfnisse der Lernenden angepasst sind
		Anpassung an individuelle Bedürfnisse	B4	Material kann verändert und an individuelle Bedürfnisse angepasst werden
		Verschiedene Lernwege	B5	Material eröffnet verschiedene Lernwege
C	Umgebung der Lernenden	Lernszenarien	C1	Verwendung des Materials für verschiedene Arten von Gruppen- und Einzelarbeit
		Lernumgebungen	C2	Verwendung des Materials in verschiedenen physischen und digitalen Lernumgebungen
		Formate	C3	Verfügbarkeit des Materials in verschiedenen Formaten
D	Lernfeedback für Lernende	Feedbackformate	D1	Material beinhaltet verschiedene Formate von Feedback
		Reflexion des Lernprozesses durch Feedback	D2	Nutzung des Feedbacks zur Reflexion des Lernprozesses
E	Reflexion der Lernenden über das Lernen	Hinweise auf Lernstrategien	E1	Material beinhaltet Hinweise auf verschiedene Lernstrategien und -techniken
		Reflexion des Lernprozesses	E2	Material regt dazu an, den eigenen Lernprozess zu reflektieren
F	Selbstwirksamkeit	Entscheidungen im Lernprozess	F1	Material ermöglicht es Lernenden, eigene Entscheidungen im Lernprozess zu treffen
		Steuerung und Kontrolle des Lernprozesses	F2	Lernende werden als fähig angesehen, ihren eigenen Lernprozess zu steuern und zu kontrollieren
		Reflexion des Stoffes	F3	Material befähigt Lernende zur kritischen Reflexion des enthaltenen Stoffes
		Vielfalt der Lernhintergründe	F4	Material berücksichtigt die Vielfalt der Lernhintergründe in Bezug auf Identitäten, soziale, familiäre, kulturelle, religiöse und gesellschaftliche Hintergründe
G	Inklusionssensibilität	Hinweise auf Inklusion	G1	Material gibt (theoretische) Hinweise auf Inklusion
		Inklusiv gestaltete Materialien	G2	Material ist inklusiv gestaltet
		Anpassung an individuelle Bedürfnisse	G3	Material kann an individuelle Bedürfnisse angepasst werden, um so inklusive Ansprüche zu erfüllen
H	OER	Lizenz und Nutzungsmöglichkeiten	H1	Lizenz des Materials und die darauf basierenden potenziellen Nutzungsmöglichkeiten
		Anpassung an Lehrkontexte	H2	Material kann aufgrund der Lizenz an Lehrkontexte angepasst werden

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Auch die Subkategorien der einzelnen Hauptkategorien für diesen Meta-Review wurden (größtenteils) deduktiv gebildet. Grundlage für die Bildung der Subkategorien waren die Leitfragen zu den einzelnen Hauptkategorien, die auf der entsprechenden Website des Projekts digiLLM (o. J. a) zu finden sind. Die Subkategorien wurden jeweils mit dem Großbuchstaben der zugehörigen Hauptkategorie sowie einer Zahl gekennzeichnet (Tabelle 1, Spalte 3). Anhand des deduktiv gebildeten Kategoriensystems wurde anschließend das gesamte Datenmaterial der vier Reviews codiert. Bei der Codierung im Sinne der qualitativen Inhaltsanalyse wird der Text Zeile für Zeile – also sequenziell – durchgearbeitet und abschnittsweise Kategorien zugewiesen. Im vorliegenden Fall wurden zudem nach dem ersten Codierprozess induktiv sieben weitere Subkategorien gebildet. Diese sind in Tabelle 1 grün markiert. Für diesen Meta-Review wurde somit insgesamt eine deduktiv-induktive Kategorienbildung durchgeführt (Kuckartz & Rädiker, 2022, S. 102).

Im Anschluss an die Kategorienbildung findet gewöhnlich eine Systematisierung und Organisation der Kategorien statt (Kuckartz & Rädiker, 2022, S. 66, 138). Das daraus resultierende Kategoriensystem umfasste acht Hauptkategorien mit jeweils zwei bis acht Subkategorien. In einem nächsten Schritt wurde erneut das gesamte Datenmaterial mit dem System aus Hauptkategorien und den gebildeten Subkategorien codiert. Kuckartz und Rädiker (2022) beschreiben dies als einen „zweiten Codierprozess“ (S. 129).

Nach Abschluss des zweiten Codierprozesses kommen in der inhaltlich strukturierenden qualitativen Inhaltsanalyse nach Kuckartz und Rädiker (2022, S. 147) einfache und komplexe Analysen zum Einsatz. Dabei stehen die herausgearbeiteten Themen und Subthemen im Mittelpunkt der Auswertung. In diesem Meta-Review erfolgen die inhaltliche Analyse der Ergebnisse und der inhaltliche Vergleich der Reviews anhand der kategorienbasierten Analyse entlang der deduktiv gebildeten Hauptkategorien (siehe Kapitel 4).

4 Ergebnisse

In den nachfolgenden Abschnitten werden die Ergebnisse des Meta-Reviews durch eine vergleichende Analyse entlang der acht Kategorien sowie ausgewählter Subkategorien exemplarisch präsentiert.

4.1 Ausgewählte Ergebnisse der Kategorie A

In allen vier Reviews wird der Aufbau des Materials (A1) als „sehr positiv“ (Review 1) bewertet. Sowohl die ausführlichen Erläuterungen zum Materialaufbau im Leitfaden (Review 3) als auch die Navigationsfunktion für das interaktive Tafelbild (Review 2) erachten die Rezensentinnen als förderlich. Positiv äußern sich Rezensentin 1 und Rezensentin 2 auch zur Materialauswahl (A2). Beide heben hervor, dass sich bei der Auswahl am Wissen der Lernenden orientiert wurde.

Die Materialverwendung im Unterricht (A4) wird in allen vier Reviews ausführlicher behandelt als andere Subkategorien. Alle Rezensentinnen weisen auf die methodisch-didaktischen Erläuterungen für Lehrkräfte und konkrete Vorschläge für den Einsatz des Materialpakets im Unterricht hin, die im korrespondierenden Leitfaden zu finden sind. Diese Hinweise zur Materialverwendung im Unterricht werden durchgehend positiv bewertet. Rezensentin 2 merkt beispielsweise an, dass dadurch „der logische Aufbau des Stoffes und der Einsatz der Materialien verständlich gemacht“ werden.

In allen vier Reviews finden sich außerdem ähnliche Einschätzungen zur Berücksichtigung des Inklusionsaspekts im Material (A5). Übereinstimmend wird festgestellt, dass das Material Inklusion nicht explizit thematisiert. Im Gegensatz zu den drei anderen Reviews sieht eine Rezensentin jedoch Ansätze im Material, die „unterschiedliche Lernbedürfnisse berücksichtigen“ (Review 4).

Hinsichtlich der verwendeten Quellen (A7) im Materialpaket besteht dahingehend Konsens, dass die

Quellenlage als unzureichend bewertet wird. Eine Rezensentin bemängelt, dass „nahezu nie ersichtlich“ (Review 2) ist, woher die Informationen des Materialpakets stammen. In anderen Reviews werden mangelnde Transparenz und Verlässlichkeit der wenigen verwendeten Quellen kritisiert. Review 3 und Review 4 äußern sich außerdem zur induktiv gebildeten Kategorie A8, theoretische Hintergründe. Beide Rezensentinnen weisen darauf hin, dass es zwar eine gewisse Basis an theoretischen Hintergründen im Material gibt, diese aber oft knapp gehalten sind. Positiv hervorgehoben wird von Rezensentin 3 die Bereitstellung einer Linkliste, die weiterführende Informationen für Lehrkräfte bietet.

4.2 Ausgewählte Ergebnisse der Kategorie B

Hinsichtlich unterschiedlicher Komplexitätsgrade (B1) erfolgen die Bewertungen anhand verschiedener Aspekte. Das Fehlen einer expliziten Staffelung der Aufgaben nach Schwierigkeitsgraden wird in Review 1 bemängelt. Review 2 nennt ein paar differenzierte Arbeitsblätter, merkt allerdings auch an, dass nur ein geringer Teil des gesamten Materials in unterschiedlichen Komplexitätsstufen angeboten wird. In Review 3 werden insbesondere der hohe Textanteil der Arbeitsblätter und die fehlende Anpassung an verschiedene Lesekompetenzen als Hauptkritikpunkte genannt, „sodass für Kinder, die nicht so gut lesen können, die Arbeitsblätter sehr herausfordernd sein können“. Die vierte Rezensentin äußert sich in ihrem Review nicht zu verschiedenen Komplexitätsgraden der Aufgaben.

Bezüglich der Anpassung des Materials an individuelle Bedürfnisse der Lernenden (B4) heben alle Rezensentinnen die Offenheit des Materialpakets aufgrund der Veröffentlichung unter einer offenen Lizenz hervor. Die dadurch mögliche Anpassung des Materials durch die Lehrkraft sehen alle vier Studentinnen als positiv. Gleichzeitig wird in Review 2 aber kritisiert, dass das Material in der zum Download bereitgestellten Version noch nicht an individuelle Bedürfnisse angepasst ist.

4.3 Ausgewählte Ergebnisse der Kategorie C

In Bezug auf den Einsatz des Materials in verschiedenen Lernszenarien (C1) schreiben die Rezensentinnen dem Materialpaket große Flexibilität zu. Eine Rezensentin stellt zwar fest, dass die meisten Aufgaben für Einzelarbeit gestellt sind (Review 2), doch in allen anderen Reviews wird das Material als gleichermaßen für den Einsatz in Einzel-, Partner:innen- und Gruppenarbeit geeignet bewertet.

Auch die Vielseitigkeit des Materials in Bezug auf verschiedene physische und digitale Lernumgebungen (C2) heben alle Rezensentinnen positiv hervor. Besonders betonen sie die Möglichkeit, das Material sowohl digital als auch in ausgedruckter Form zu bearbeiten (Review 1, Review 2, Review 3). Darüber hinaus wird die Flexibilität, die Aufgaben sowohl in der Schule als auch zu Hause bearbeiten zu können, positiv bewertet (Review 2, Review 3, Review 4). Insgesamt sind sich die Rezensentinnen einig, dass das Materialpaket „weitgehend anpassungsfähig für verschiedene Umgebungen“ (Review 4) ist.

4.4 Ausgewählte Ergebnisse der Kategorie D

Die Bewertungen zu den Feedbackformaten (D1) im Material variieren. Zwei Rezensentinnen (Review 1, Review 3) bemängeln, dass es keine Feedbackformate in Form von Rückmeldungen oder Selbsteinschätzungen gibt. In den beiden anderen Reviews und auch in Review 1 wird jedoch die Selbstüberprüfungsfunktion für die interaktiven Übungen, bei der richtige und falsche Lösungen angezeigt werden, als vorhandenes Feedbackformat hervorgehoben (Review 1, Review 2, Review 4). Eine Rezensentin merkt außerdem an, dass alle anderen Feedbackarten, insbesondere zu Arbeitsblättern, durch die Lehrkraft erteilt werden müssen (Review 1).

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Inwiefern die begrenzt vorhandenen Feedbackformate zur Reflexion des Lernprozesses führen (D2), wird in den Reviews einheitlich bewertet. Alle Rezensentinnen sind sich einig, dass die Feedbackformate keinerlei bzw. keine explizite oder tiefergehende Reflexion über den Lernprozess anregen. Lediglich in Review 4 werden die interaktiven Elemente und explorativen Aufgaben als indirekte Anregung zur Reflexion angeführt.

4.5 Ausgewählte Ergebnisse der Kategorie E

In Bezug auf die Hinweise zu Lernstrategien (E1) und die Reflexion des Lernprozesses (E2) herrscht Einigkeit unter den Rezensentinnen. Alle bemängeln, dass das Material keine expliziten Erklärungen oder Hinweise zu Lernstrategien enthält und auch keine Ansatzpunkte bietet, die die Lernenden aktiv zum Reflektieren ihres Lernprozesses anregen könnten. Zwei Rezensentinnen heben jedoch „indirekte Ansätze, die die Lernenden ermutigen könnten, eigene Strategien zu entwickeln“ (Review 4) hervor. Als Beispiel dafür nennt Rezensentin 1 ein Arbeitsblatt, während Rezensentin 4 auf die interaktiven Elemente des Tafelbilds verweist.

4.6 Ausgewählte Ergebnisse der Kategorie F

Die vergleichende Analyse der vier Reviews zeigt eine gemischte Einschätzung bezüglich der Entscheidungsfreiheit der Lernenden im Lernprozess (F1). Zwei Rezensentinnen (Review 2, Review 3) sehen keine oder sehr begrenzte Möglichkeiten für eigene Entscheidungen der Lernenden. Die anderen beiden Rezensentinnen (Review 1, Review 4) nennen Beispiele dafür, dass die Lernenden in bestimmten Phasen des Lernprozesses eigenständige Entscheidungen treffen können.

Dieses uneinheitliche Meinungsbild setzt sich in den Bewertungen zur Steuerung und Kontrolle des Lernprozesses (F2) fort. Drei Rezensentinnen (Review 1, Review 2, Review 3) kritisieren, dass die Lernenden bei der Beschäftigung mit dem Material ihren eigenen Lernprozess nicht steuern oder kontrollieren können. Es wird sogar von einer Rezensentin konstatiert, „dass die Autor*innen des Materials die Lernenden nicht als fähig ansehen, ihren eigenen Lernprozess zu steuern und zu kontrollieren sowie die Inhalte kritisch zu reflektieren“ (Review 2). Lediglich in Review 4 werden die explorativen Elemente des Materialpakets als förderlich für die Selbststeuerung der Schüler:innen hervorgehoben.

Auch die Reflexionsmöglichkeiten des Stoffes (F3) werden in den Reviews unterschiedlich bewertet. Rezensentin 2 bemängelt das Fehlen jeglicher Möglichkeit zur kritischen Reflexion im Material. Hingegen werden in Review 3 die Materialien zur Globalisierung als positive Beispiele hervorgehoben, die zur kritischen Auseinandersetzung anregen. Laut Rezensentin 4 regen die im Materialpaket behandelten Themen zur kritischen Auseinandersetzung und Reflexion an.

Die Vielfalt der Lernhintergründe (F4) wird in den Reviews in Bezug auf verschiedene Aspekte ambivalent beurteilt. Vor dem Hintergrund der Vielfalt der Lernenden in Bezug auf ihre Identitäten sowie ihre gesellschaftliche, familiäre, kulturelle und religiöse Herkunft wird von zwei Rezensentinnen (Review 2, Review 4) positiv bewertet, dass in dem Material durch die behandelten Themen unterschiedliche Perspektiven berücksichtigt werden. In Bezug auf die unterschiedlichen Lernniveaus wird indes negativ bewertet, dass verschiedene Lernhintergründe in den Arbeitsmaterialien nicht beachtet werden (Review 3, Review 4). Ein weiterer Aspekt, der in Review 2 kritisiert wird, ist die stereotype Darstellung von Menschen aus verschiedenen Weltregionen.

4.7 Ausgewählte Ergebnisse der Kategorie G

Die Abschlussbewertung zur Inklusionssensibilität des Materials (G) ist ambivalent. Nicht in allen Reviews

finden sich Äußerungen zu jeder induktiv gebildeten Subkategorie. Die vergleichende Analyse zeigt, dass zwei Rezensentinnen (Review 1, Review 3) bemängeln, dass konkrete Hinweise hinsichtlich Inklusion (G1) im Material fehlen. In drei Reviews wird festgestellt, dass das Materialpaket keine inklusiv gestalteten Materialien (G2) enthält und somit nicht auf die individuellen Bedürfnisse der Lernenden eingeht (Review 1, Review 2, Review 3). Lediglich nach Ansicht einer Rezensentin ermöglicht das Material „den Zugang zu komplexen Themen auf unterschiedliche Weise“ (Review 4). Positiv wird von allen Rezensentinnen bewertet, dass das Material an die individuellen Bedürfnisse der Lernenden angepasst werden kann (G3).

4.8 Ausgewählte Ergebnisse der Kategorie H

Ein Blick auf die Abschlussbewertung zur OER (H) zeigt eine einheitlich positive Bewertung. In den Reviews wird positiv hervorgehoben, dass das Material unter der offenen Lizenz CC BY-SA 4.0 veröffentlicht ist und daher verändert, verbreitet und neu zusammengestellt werden darf (H1). In den Reviews werden außerdem die Anpassungsmöglichkeiten an verschiedene Lehrkontexte mehrfach positiv beurteilt (H2). Dabei heben zwei Rezensentinnen (Review 2, Review 3) insbesondere die Anpassung an individuelle Bedürfnisse der Lernenden hervor.

5 Diskussion

Im Folgenden werden das Vorgehen für diesen Meta-Review sowie die vorgestellten Ergebnisse der vergleichenden Analyse unter verschiedenen Gesichtspunkten interpretiert und diskutiert. Außerdem werden zusammenfassende Aussagen über die Gesamtbewertung des Materialpakets „Wie die Welt zusammenwächst“ (Siemens Stiftung, 2016) getroffen.

Zunächst zeigt der Meta-Review, dass der FRoLLM als Rahmen für Reviews von Lern- und Lehrmaterialien ein gelungenes Reflexionsinstrument darstellt. Durch die Leitfragen zur Reflexion und die dazugehörigen detaillierten Indikatoren wird eine intensive Auseinandersetzung mit und Reflexion über das Material angeregt. Im Rahmen der vergleichenden Analyse wurden die inhaltlichen Gemeinsamkeiten und Unterschiede der Reviews kategorienbasiert herausgearbeitet. Etwa zwei Drittel der in den Subkategorien erfassten Aspekte wurden von den Rezensentinnen entweder einheitlich positiv oder übereinstimmend negativ bewertet. In den Begründungen für die jeweiligen Bewertungen lassen sich häufig ähnliche Beobachtungen, Einschätzungen und Argumentationsmuster in Bezug auf das untersuchte Material erkennen. Ein Beispiel hierfür ist die Subkategorie G3: Die Rezensentinnen bewerten die Inklusionssensibilität des Materials übereinstimmend positiv. Insbesondere die Möglichkeit für Lehrkräfte, das Material flexibel an die individuellen Bedürfnisse der Lernenden anzupassen, wird von drei Rezensentinnen positiv beurteilt (Review 2, Review 3, Review 4). Diese Übereinstimmung deutet darauf hin, dass diese Rezensentinnen der Lehrkraft eine zentrale Bedeutung bei der Umsetzung inklusiver Bildungsprozesse beimessen. In Übereinstimmung mit Brückner (2018) betrachten sie Lehrpersonen als „autonome, kreative und kompetente Lehrende“ (S. 51), die OER an die Bedürfnisse der Lernenden anpassen. Dieses geteilte Verständnis spiegelt sich auch in zahlreichen weiteren Passagen der Reviews wider. Eine mögliche Erklärung hierfür könnte sein, dass alle Befragten den gleichen Studiengang belegen und kollektive Berufserfahrungen teilen.

Im Gegensatz dazu zeigt sich bei etwa einem Drittel der untersuchten Kriterien eine uneinheitliche Bewertung des Materials. In diesen Fällen äußern die Rezensentinnen unterschiedliche positive und negative Argumente innerhalb derselben Subkategorie. Dies betrifft beispielsweise die inklusive Gestaltung der Materialien (G2) und die Vielfalt der Lernhintergründe (F4). Hier lassen sich die Unterschiede in den Bewertungen möglicherweise auf unterschied-

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liche Auffassungen der Rezensentinnen hinsichtlich spezifischer Sachverhalte und Konzepte zurückführen. Als Beispiel dafür kann etwa die Subkategorie G2 angeführt werden: Lediglich eine Rezensentin ist der Ansicht, dass das Material „den Zugang zu komplexen Themen auf unterschiedliche Weise“ (Review 4) ermöglicht. Alle anderen Rezensentinnen kommen zu der Bewertung, dass mit dem Material nicht auf die individuellen Bedürfnisse der Lernenden eingegangen wird. Die Auffassung von Rezensentin 4 bezüglich eines inklusiv gestalteten Materials unterscheidet sich somit von denen der anderen Rezensentinnen.

Zusammenfassend lässt sich festhalten, dass es sich bei den vorliegenden Reviews um ein qualitatives Bewertungsformat handelt. Die individuelle Beurteilung des Materials ist dabei von mehreren Faktoren abhängig, darunter die Intensität der Auseinandersetzung mit dem Material, der Grad der Reflexion, persönliche Schwerpunktsetzungen, individuelle Erfahrungen und Interessen, die Beschaffenheit des Materials selbst sowie das subjektive Verständnis pädagogischer Konzepte.

Im Rahmen dieses Meta-Reviews lassen sich auf Grundlage der inhaltlich vergleichenden Analyse der Reviews zusammenfassende Aussagen über die Gesamtbewertung des Materialpakets „Wie die Welt zusammenwächst“ (Siemens Stiftung, 2016) treffen. Die Analyseergebnisse zeigen, dass das Materialpaket in vielen Aspekten gut strukturiert und didaktisch sinnvoll aufgebaut ist. Übereinstimmend positiv bewertet werden der logische Aufbau (A1), die Materialauswahl (A2) und die didaktische Unterstützung für Lehrkräfte bezüglich der Materialverwendung im Unterricht (A4). Verbesserungsbedarf besteht hingegen vor allem bei der Erklärung der Absichten und Einschränkungen hinsichtlich Inklusion (A5), der Anzahl und Transparenz der verwendeten Quellen (A7) sowie der theoretischen Fundierung (A8). Gezielte Ergänzungen in diesen Bereichen könnten Qualität und Verlässlichkeit des Materials steigern sowie eine breitere Anwendbarkeit ermöglichen. Insbesondere die Kennzeichnung verwendeter Quellen ist von großer Wichtigkeit, um zu verhindern, dass OER „zum Vehikel zur politischen Infiltration und zur Beeinflussung von Meinungen“ (Kerres, 2019, S. 6) werden.

Das Materialpaket enthält vereinzelt Ansätze für unterschiedliche Komplexitätsgrade (B1), die jedoch nicht konsequent im gesamten Material umgesetzt werden. Die Möglichkeit zur Anpassung an individuelle Lernbedürfnisse (B4) durch Lehrkräfte wird zwar mehrheitlich als positiv bewertet, entlässt das Materialpaket jedoch aus der Verantwortung, bereits integrierte Differenzierungsmaßnahmen bereitzustellen. Nach Ansicht von Brückner (2018) muss in ein einem solchen Fall die „Einpassung, Anpassung und auch Modifikation […] von den Lehrkräften selbst übernommen und ebenfalls verantwortet werden“ (S. 56). Dennoch können Lehrpersonen nach Einschätzung von Müller (2019, S. 2) auf diese Weise differenzierte Unterrichtsangebote schaffen, die den individuellen Bedürfnissen der Lernenden gerecht werden, und doch gleichzeitig durch OER in der Vorbereitung ihrer Lehre entlastet werden.

Der Meta-Review verdeutlicht, dass das Materialpaket aufgrund seiner Vielseitigkeit und Flexibilität in verschiedenen Lernszenarien (C1) und Lernumgebungen (C2) im Unterricht und darüber hinaus einsetzbar ist. In Bezug auf Feedbackformate (D1) und die Reflexion des Lernprozesses durch diese (D2) weist das Material allerdings Schwächen auf. Es bietet lediglich oberflächliche, quantitative Rückmeldungen ohne strukturierte Feedbackmechanismen für die Lernenden. Dadurch werden weder eine tiefergehende Auseinandersetzung mit den Lerninhalten noch die aktive Reflexion des Lernprozesses angeregt. Um zu gewährleisten, dass die Lernenden nicht nur ihre Fehler erkennen, sondern auch tiefere Einsichten in ihren eigenen Lernprozess gewinnen können, gilt es daher, die Feedback- und Reflexionsmöglichkeiten zu erweitern.

Auch im Bereich der Reflexion der Lernenden über das Lernen (E) gibt es Verbesserungspotenzial.

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Das untersuchte Materialpaket bietet weder direkte Hinweise auf mögliche Lernstrategien (E1), noch fördert es gezielt die Reflexion des Lernprozesses (E2). Auch die Selbstwirksamkeit der Lernenden (F) wird durch das Materialpaket nur begrenzt gefördert. Die wenigen Möglichkeiten für Entscheidungen der Lernenden in ihrem Lernprozess (F1) sowie zur Steuerung und Kontrolle des Lernprozesses (F2) werden durch die vorgegebene Struktur des Materials limitiert. Auch Reflexionsmöglichkeiten bezüglich der Lerninhalte (F3) sind nur in geringem Umfang gegeben. Insbesondere OER – wie dieses Materialpaket – bieten häufig die Möglichkeit einer individuellen und handlungsorientierten Auseinandersetzung mit den Lerninhalten. Doch dabei ist gerade die aktive Beteiligung der Lernenden am Lernprozess entscheidend (Müller, 2019). Auch für die Weiterentwicklung von Materialien betrachtet Müller (2016) das Feedback von Schüler:innen als essenziell, da nur so die „Passung zwischen Material und Person zu verbessern“ (S. 42) ist. Die differenzierte Berücksichtigung von Lernhintergründen (F4) ist in dem hier untersuchten Materialpaket jedoch oft eingeschränkt. Das ließe sich u.a. durch stärkere Orientierung an den unterschiedlichen Lebenswelten der Lernenden ändern, die den Schüler:innen eine stärkere Identifikation mit dem Material ermöglichen und somit die Relevanz der Lerninhalte erhöhen könnte (Müller, 2019).

Insgesamt könnte das Materialpaket durch mehr Wahlmöglichkeiten für Lernende, systematische Reflexionsaufgaben und eine differenzierte Gestaltung – u.a. mit Blick auf die verschiedenen Lernniveaus der Schüler:innen – signifikant verbessert werden. Abschließend wird das interaktive Tafelbild von den Rezensentinnen in der Bewertungskategorie Inklusionssensibilität durchschnittlich mit 48% beurteilt (digiLLM, o. J. c). Explizite Hinweise auf Inklusion (G1) fehlen in diesem Materialpaket jedoch. Zudem sind die Materialien nicht differenziert genug, um verschiedene Lernbedürfnisse zu berücksichtigen (G2). Das können allerdings die Lehrenden, die damit arbeiten, ändern. Müller (2016, S. 38) ist der Ansicht, dass OER wie das hier evaluierte Materialpaket dadurch einen Beitrag zur Umsetzung eines inklusiven Bildungssystems leisten können, dass sie Lehrkräften die Anpassung an die individuellen Bedürfnisse der Lernenden ermöglichen. Auf diese Weise kann die Inklusionssensibilität in der Praxis erhöht werden. Die Möglichkeit der Anpassung an Lehrkontexte (H2) und die vielfältigen Nutzungsmöglichkeiten des Materials (H1) werden im vorliegenden Fall durch die Creative-Commons-Lizenz, unter der das Material veröffentlicht wurde, ermöglicht. Das Materialpaket wird daher auch in allen vier Abschlussbewertungen zu 100% als OER bewertet. Als OER darf das Material somit in Anlehnung an die fünf Vs verwahrt bzw. vervielfältigt, verwendet, verarbeitet, vermischt und verbreitet werden (Muuß-Merholz, 2015).

6 Fazit

In diesem Meta-Review wurden vier Reviews zu dem Materialpaket „Wie die Welt zusammenwächst“ (Siemens Stiftung, 2016) aus dem Medienportal der Siemens Stiftung zusammengeführt. Diese vier Reviews wurden im Rahmen des Projekts digiLLM mit Hilfe des FRoLLM erstellt. Bei dem FRoLLM handelt es sich um ein geeignetes Reflexionstool für die Erstellung eines Reviews zu einem Materialpaket. Eine intensive Auseinandersetzung mit und Reflexion über das Material wird angeregt. Bildungsmaterialien werden in Hinblick auf ihre Inklusionssensibilität bewertet. Mittels dieses Meta-Reviews konnten die Ergebnisse der vier Reviews zu dem Materialpaket systematisiert werden. Gemeinsamkeiten und Unterschiede der Reviews wurden in einer inhaltlich vergleichenden Analyse (Kuckartz & Rädiker, 2022) herausgearbeitet. Dabei wurde deutlich, dass es sich bei diesen Reviews um individuelle Beurteilungen des Materials handelt, die von mehreren Faktoren abhängig sind. Unter anderem die Intensität der Auseinandersetzung mit dem Material, der Grad der Reflexion, persönliche Schwerpunktsetzungen, individuelle Erfahrungen und Interessen, die Beschaffenheit

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des Materials selbst sowie das subjektive Verständnis pädagogischer Konzepte beeinflussen die Bewertung des Materials.

Die Zusammenführung der Analyseergebnisse ermöglicht eine zusammenfassende Bewertung des Materialpakets „Wie die Welt zusammenwächst“ (Siemens Stiftung, 2016). Insgesamt wird das interaktive Tafelbild als gut strukturiert und didaktisch sinnvoll bewertet, insbesondere in Bezug auf den logischen Aufbau, die Materialauswahl und die fest in das Materialpaket integrierte Unterstützung für Lehrkräfte. Verbesserungsbedarf besteht vor allem in Bezug auf die Transparenz der Quellen, die theoretische Fundierung und die Berücksichtigung von Inklusion. Während das Material eine gewisse Flexibilität bietet, die eine Anpassung an unterschiedliche Lernszenarien ermöglicht, fehlen systematische Reflexionsmöglichkeiten, Feedbackformate für die Lernenden und integrierte Differenzierungsmaßnahmen. Trotz dieser Schwächen ermöglicht die Lizenz als OER eine individuelle Anpassung, wodurch Lehrkräfte das Material inklusiver gestalten und gezielt auf die Bedürfnisse der Lernenden abstimmen können.

Die aktive Auseinandersetzung mit und Reflexion über Lehr- und Lernmaterialien, insbesondere OER, sind zentrale Elemente einer inklusiven Schulpraxis. Durch den Einsatz inklusiv gestalteter Materialien können für alle Schüler:innen vielfältige Lernerfahrungen geschaffen werden. Das Projekt digiLLM und der FRoLLM als Bewertungsinstrument für die Inklusionssensibilität von Bildungsmaterialien haben hilfreiche Ansätze vermittelt, die bei der Auswahl von Unterrichtsmaterialien und der Gestaltung eines inklusiven Unterrichts gezielt genutzt werden können.

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The “Project 2” English Language Textbook for Lower Secondary Schools

Meta-review of Learning Material Evaluations

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Abstract:

English is the first foreign language that pupils encounter in Czech primary schools. It is a mandatory part of the curriculum, which aims to develop language competencies through a combination of reading, writing, listening, and active communication. Barriers to teaching in Czech schools include a persistent shortage of qualified teachers and the diverse skill levels of students who come from varied backgrounds. The goal of this meta-review of the digital English language textbook “Project 2” (Hutchinson, 2018) is to identify and evaluate, using the FRoLLM framework, the extent to which inclusive elements are incorporated in the textbook. The analysis examines inclusion parameters and their fulfilment through the content and didactic structure of the textbook. We believe that diverse instructional activities and formats contribute, particularly in foreign language learning, to more effective language acquisition and increased student motivation (Černá, 2018; Haas et al., 2018). The meta-review yielded several insights. While the “Project 2” English language textbook is clearly structured and logically organized, its potential in terms of inclusive elements is not sufficiently developed or anchored in the methodology. The textbook authors do not explicitly state an inclusive approach or mention specific inclusive elements in the text. However, the material provides a selection of learning tasks with varying levels of difficulty and scaffolding support in certain lessons. Additionally, the textbook incorporates multiple representations of the content using sensory stimuli and is designed to support a variety of learning strategies. The material encourages collaborative learning and, in some cases, even facilitates peer reflection and self-assessment.

Keywords:

meta-review; textbook analysis; inclusion; digital learning material; theoretical frameworks; English language

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1 Introduction

A wide range of printed and, more recently, digital teaching materials is used to teach English in Czech schools. The selection of textbooks is usually made by subject committees, which bring together teachers of the same or related subjects, in this case foreign languages. The commissions cooperate in the areas of teaching methodology and didactics, develop the curricular framework for each individual subject, provide methodological support for working with pupils with special educational needs, and, among other responsibilities, monitor the availability of teaching aids, including textbooks. The subject committees propose to the school principal the purchase of specific educational resources that best match the students' level of knowledge and align with the school curriculum. Given the different levels of language proficiency and the diverse backgrounds of students, selecting a universally applicable foreign language textbook is challenging. Some textbooks emphasize grammar and traditional instructional methods (e.g., explanation, presentation, individual reading, "fill-in-the-blank" exercises), while others favor constructivist approaches to language acquisition, especially active work with the language, discovering its structure, communicating in real situations, task-based learning, and student projects. Comparing different teaching methodologies and official educational resources can help educators select the most appropriate materials based on students' age, proficiency level, and learning needs.

The "Project 2" English language textbook (Hutchinson, 2018) is a widely used resource in Czech schools. It is designed for students in the 6th and 7th grades of lower secondary school or the lower grades of grammar schools, corresponding to levels A1 and A2 of the Common European Framework of Reference for Languages – CEFR (Council of Europe, 2020). The textbook is adopted in its original format, designed for non-English speaking countries in general, and therefore does not strictly incorporate elements of the Czech curriculum. Project 2 builds on previous knowledge of the English language and emphasizes communication skills in real-life situations. Additionally, it focuses on vocabulary development, common phrases, and expressions used in everyday contexts.

The textbook package (textbook and workbook) includes multimedia support in the form of audio and video recordings, providing students with exposure to authentic spoken language in diverse contexts. While a traditional printed version of the textbook and workbook exists, this meta-review focuses on the enhanced digital version. Unlike a standard e-book that simply replicates the print edition, this digital version offers additional interactive features. Students can complete tasks directly on a digital platform, navigate through the content intuitively, access supplementary exercises, and receive immediate feedback on their answers. This interactive format is designed to support more autonomous and engaged learning. While the textbook is provided to students free of charge at school, the workbook, which contains the code for the digital materials, must be purchased separately. An abbreviated version of the textbook can be found on the website of the publisher.

Given the dynamic nature of English as a foreign language, continuous content updates are necessary to ensure relevance. This meta-review of Project 2 is conducted at a time when the Czech Ministry of Education, Youth, and Sports (MŠMT) has introduced a significant curricular reform. From the 2025/26 school year, schools may voluntarily begin teaching English from the first grade, with mandatory implementation for grades 1 and 6 starting in September 2027, and full implementation across all primary grades by September 2031 (MŠMT, 2024). In addition, the reform aims to raise the expected exit level of English for ninth-grade students to B2 according to the CEFR, a significant increase from the current A2 level. These policy changes increase the demand for high-quality educational resources and well-qualified teachers capable of effectively implementing them.

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2 Methodology

The main research question for creating a meta-review of the textbook was "What types of inclusive elements are included in the English language textbook Project 2 and how are these elements presented by the textbook for student learning?" The aim of the meta-review was to compare three sub-analyses (i.e., three in-depth analyses; see below) of the English language textbook and create a synthesis of its attributes in relation to the inclusive elements of the learning material. In this article, we consider a meta-review to be a "review of reviews" (Hunt et al., 2018) as well as an "umbrella review" (Aromataris et al., 2015) that provides a systematic and transparent treatment of existing studies and offers a comprehensive view of a particular topic. It is a form of knowledge synthesis that aims to bring together existing evidence from various thematic reviews in a given area and focus on the commonalities and differences of the sub-reviews (Ridley, 2012).

The meta-review of the English language textbook Project 2 was based on three evaluations conducted in November 2024 by students enrolled in teacher education programs at the University of Ostrava. Each review was carried out independently using the FRoLLM worksheet (see below) following prior training of all participants and their familiarization with the analytical framework for the didactic evaluation of teaching materials. The training was provided within the course "Curriculum", which forms part of the undergraduate program for future teachers. Before analyzing Project 2, a pilot study was conducted on teaching materials from a different publishing house to refine the methodology and clarify the criteria for inclusive education.

The aim of this meta-review was to systematically assess the textbook's inclusive elements and synthesize the reviewers' findings. Additionally, the study sought to identify key agreements and differences in the reviewers' perspectives on the design of educational materials. The textbook was evaluated using the Framework for the Reflection on Living Learning Materials (FRoLLM), developed within the *DigiLLM* project to support the creation of inclusive educational resources. This framework ensures that materials are differentiated and effectively address the learning needs, strategies, and contexts of individual students within heterogeneous classes.

The analysis was structured around the six predefined thematic domains of the FRoLLM framework: (1) Philosophy and Design, (2) Learners' Needs, (3) Learners' Environment(s), (4) Learning Feedback for Learners, (5) Learners' Reflections on Learning, and (6) Learners' Agency. Each domain was further defined by specific indicators and guiding questions. Reviewers rated the presence of inclusive elements in the educational material on a 1–5 scale (symbolized by stars). The rating scale was included in the text of the grid template.

The following criteria were respected when creating the meta-review: systematicity (in this case, reviews were conducted according to the agreed-upon FroLLM framework), transparency in the selection of studies, relevance of studies, synthesis of common features and differences between studies, and finding an answer to the research question (Petticrew & Roberts, 2006). We believe that the synthesis of individual reviews will allow for a more comprehensive view of the inclusivity of the evaluated educational resources.

3 Analysis and Synthesis

This chapter provides a synthesis of the evaluation findings concerning the Project 2 digital English language textbook. The analysis, conducted by three reviewers, focuses on six key areas defined by the FroLLM framework.

3.1 Area 1: Philosophy and Design of the Material

The first analyzed aspect of the learning material was its **philosophy and design**. When evaluating the Philosophy and Design of the learning materials, the authors of the individual analyses agree that the textbook is well-structured and logically organized. The material provides explanations regarding its structure, selection, and design. At the beginning of the textbook, a clear table summarizing the topics of each lesson can be found, including grammar, vocabulary, communication, and skills. This table offers a structured overview of the content and focus of individual chapters. Additionally, each lesson contains a revision or progress check, which contributes to the systematic reinforcement of learning. The workbook, which forms a didactic complex with the main textbook, does not include tables or color distinctions but maintains the same structural organization. This consistency helps students navigate the material and manage their learning. Reviewer 1 states: "I appreciate that the chapters are divided into clear sections, each distinguished by a specific color (e.g., green for grammar). This consistent use of color coding—such as green headings for grammar tasks—makes the material easy to navigate." Reviewer 2 notes that

> each chapter also includes a 'Revision' section designed for reviewing the material covered. The textbook uses clear visual cues, such as a headphone icon for activities focused on listening. This use of color and graphic organization helps both students and teachers navigate the material more easily.

The Project 2 textbook also includes practical knowledge and conversational topics applicable to real-life situations.

The reviewers highlight the clarity of topic organization and the relevance of content in relation to student motivation. Reviewer 2 appreciates the section at the end of the textbook that is intended for students and provides accessible explanations of methodology, grammar concepts, and strategies for language learning. He also highlights that the textbook includes a variety of tasks designed to develop multiple language skills and promote communication, reflecting its focus on supporting students in building comprehensive foreign language competencies.

However, reviewers also note that the material does not provide references to additional resources. "The textbook does not reference any additional educational resources. It only cites the sources of the illustrations, photographs, and music used," states Reviewer 3. "At the end of both the textbook and the workbook, there is a note stating that teachers from various countries have provided the author with feedback—comments and suggestions—on this edition."

All reviewers agree that the textbook does not explicitly describe its educational philosophy, pedagogical context, or clearly define its specific target age group or language level. The material is part of a complete learning package, which includes a student's textbook, workbook, and both printed and online formats. Based on the number two on the cover, one might correctly assume that it is the second volume in a multi-level series. The cover also states that this is the 4th edition, which refers to a revised version of this second volume, not to a newer version of a different textbook—though this could be misinterpreted by users who are unfamiliar with the series. Additionally, the textbook does not provide clear guidance on how to use the material in practice. The teacher's guide, which contains methodological instructions, is published separately.

There is no indication in the textbook regarding its alignment with the Czech national curriculum, the so-called Framework Educational Programme (Rámcový vzdělávací program, short: RVP), which defines national curriculum standards in the Czech Republic (MŠMT, 2021). Additionally, since the textbook does

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not explicitly state the language proficiency level for which it is intended, it remains unclear whether it fully meets the standards set by the national curriculum. The absence of direct links to educational standards also makes it difficult to assess its compliance with curriculum requirements. "There is a complete lack of direct connection to specific educational standards or guidelines," states Reviewer 2. For educational materials used in public schools, alignment with the RVP is essential to ensure that the content supports the development of required competencies and meets expected learning outcomes. A lack of such alignment can limit the textbook's usability in classroom settings and reduce its relevance for teachers following the national curriculum.

The authors of the textbook **do not explicitly refer to an inclusive approach**. Reviewer 2 notes: "in neither the textbook nor the workbook is there any text that directly reflects the authors' intentions or the limitations of the material in relation to inclusion. The authors themselves do not claim that the textbook has an explicitly inclusive character." Additionally, both task instructions and content are presented solely in English, which may be challenging for students with special educational needs or those whose language proficiency is lower than expected.

Overall, reviewers rate the textbook's structure positively, but due to the low implementation of inclusivity and insufficient connection to the national curriculum, they only rate it three stars.

3.2 Area 2: Learners' Needs

The next area of the FroLLM framework that was analyzed focuses on evaluating the learning resources in relation to fulfilling **Students' Needs**. All reviewers confirm **that the material offers various approaches to student learning**. The learning tasks vary in difficulty (different skill levels), ensuring that the textbook offers a broad selection of diverse exercises targeting all language skills. These include gap-filling based on listening, picture description, sentence formation without a given verb, matching words into logical pairs, pronunciation practice through listening, and reading comprehension tasks with accompanying questions. The material also features interaction-based activities, such as working with a partner and group exercises.

The workbook, which is part of the textbook package, offers graded exercises, where the difficulty is indicated by the number of stars next to each task. This feature enables teachers to adapt exercises to their students' varying skill levels.

All reviewers agree that the learning material **provides different levels of scaffolding support depending on students' learning difficulties**. Reviewer 1 provides the following example:

> [I]n the textbook, on p. 12, the part of chapter that deals with family begins. Students first listen to a text, which they also have the opportunity to read – they learn how to correctly name individual family members. In exercise 3a on p. 13, they then visualize the relationships between the family members from the previous text in a family tree. This is a good example of multisensory learning[.]

Scaffolding, i.e., specific, targeted, and temporary support provided by the teacher or (the textbook) to help students understand new material or master more complex tasks (Van de Pol et al., 2010; Yelland & Masters, 2007), is primarily represented through hints and modeling techniques. Examples of scaffolding strategies included in the textbook are model sentences and example situations, project tasks with hints, listening exercises with a native speaker, or the start of a sentence that students then need to match correctly to the rest of the statement. Reviewer 3 gives an example:

> In the Culture section there is a reading and listening task focused on a specific cultural aspect of an English-speaking country (e.g. in lesson 3).

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This is followed by a task where the student is asked to write a similar text about their place of residence using guiding questions or hints.

The learning material incorporates **various forms of content representation**, adapting to the diverse needs of students. Texts and exercises are often supplemented with visual and multimedia elements, including colorful illustrations, photo stories and dialogues, as well as a cultural section accompanied by videos. In addition to visual elements, the material offers a variety of listening exercises, which include transcripts and recordings at different speeds. While the teacher typically decides which audio material will be used during the lesson, each student has access to the full set of recordings and can choose which ones to revisit or practice with individually. This diverse approach to content representation allows students with different learning styles to engage with the material in ways that best suit their individual needs.

A key benefit of the digital format is that it allows individual users to adjust features such as the playback speed of audio recordings based on their own preferences and cognitive processing needs. Unlike in-class use of audio materials—where the teacher controls playback for all students—the digital version enables each learner to personalize their experience, thereby enhancing accessibility and supporting inclusive learning.

Although the meta-review focuses primarily on the online version of the textbook, reviewers note that access is granted via activation codes included in the printed textbook and workbook. Two of the reviewers (Reviewer 1 and Reviewer 2) note that the student version of the online resources does not include some of the advanced features available in the teacher's edition, such as answer keys: "If a student does not purchase the workbook and access code, they are limited to publicly available audio recordings on the publisher's website and cannot fully utilize the advantages of the online version." The degree of individual adaptation depends on the availability of digital tools and how they are implemented in learning. Reviewers collectively awarded the material four stars for its responsiveness to individual student needs.

3.3 Area 3: Learners' Environment

The learning material was also examined in terms of organizational work forms and the overall **learning environment**. All reviewers noted that the material includes tasks intended for individual work as well as group-based activities.

The comprehensive online version of the textbook and workbook is available in digital format, "but requires access through a subscription or license," as Reviewer 1 points out. It includes audio and video recordings with accompanying transcripts, which are particularly useful in acoustically challenging environments. "There is also a freely accessible online version; however, this version contains very few exercises, focusing solely on the grammar section and audio recordings. These recordings do not include transcripts," notes Reviewer 2. The reviewers agree that both the printed and online versions of the textbook are designed to be usable across various physical and digital learning settings.

Reviewers appreciate the diversity of learning material formats, but all criticize their accessibility, particularly the financial barrier posed by the required license, which may limit availability for some schools or students. Due to this accessibility issue, the learning environment parameter received a three-star rating from all reviewers.

3.4 Area 4: Learning Feedback for Learners

The textbook was also evaluated in terms of providing **feedback to students**. This is included, for example, in the summary of the content covered, the "Review" section or the "Progress Check". Feedback is provided in the form of answer keys for selected

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exercises and opportunities to monitor learning progress. The reviewers appreciate the feedback potential that the textbook incorporates into certain lessons; however, they disagree on its effectiveness. While two reviewers (Reviewer 1 and Reviewer 3) rated this parameter with four stars, Reviewer 2 gave it three stars. Reviewer 1 states that "the grammar exercises clearly indicate which language feature they focus on. This allows students to easily navigate the summary and, if necessary, correct their exercises, thereby providing them with an opportunity for feedback."

The reviews also note that many grammatical structures presented in the textbook are directly applicable to everyday vocabulary, enabling students to receive feedback through real-life language use.

3.5 Area 5: Learners' Reflections on Learning

The material **focuses on explaining, supporting, and encouraging the use of various learning strategies and techniques**. All reviewers agree that the material provides structured approaches that promote effective learning and the gradual acquisition of language skills. For example, in the grammar section, structured exercises guide students toward independent problem solving through a step-by-step process: (1) recognizing a grammatical concept in sample sentences, (2) describing its function, and then (3) applying the concept independently, e.g., by forming sentences in the past continuous tense. The material also includes practical language-use tasks, where students translate phrases or sentences into their native language, reinforcing both grammar and vocabulary relevant to real-life situations.

Reviewer 2 and Reviewer 3 emphasize that the textbook supports various learning strategies:

1. **Auditory learning.** Frequent use of audio recordings, often paired with text, helps students who prefer an auditory approach.
2. **Writing.** The writing section offers diverse exercises targeting different cognitive processes, fostering multi-level writing development.
3. **Communication.** The material incorporates pair and group work, dramatization, and spontaneous dialogues.

By alternating between different types of tasks, the material avoids monotony. Strategies are combined in ways that accommodate various learning styles and address diverse student needs.

Some other built-in reflective mechanisms can be found in the "Review" and "Progress Check" sections at the end of each lesson. "In the Progress Check section (in the workbook), the student can directly mark whether they feel they are already able to talk about a given topic or whether they need further review," states Reviewer 2. These sections serve as knowledge verification tools that allow students to complete exercises and then review the correct answers with the teacher to receive direct feedback on their learning progress.

All reviewers agree that some space for reflection exists, but it is limited. Many of the exercises require students to work with a partner, fostering collaboration, communication, and peer review. The material also includes individual reflection, particularly in the "Revision" and "Project" sections, which summarize broader thematic units. These sections enable students to evaluate what they have learned. Additionally, the material encourages error awareness.

Another reflective component is the "Progress Check" section, which provides students with a tool for self-assessment and ongoing progress evaluation. This feature helps students better understand their own strengths as well as identify areas for improvement in their learning processes.

The reviewers agree that the educational material supports different learning styles and accounts for

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students' diverse needs, though not to an extensive degree or consistently throughout the textbook. Therefore, they all rate this area with three stars. Reviewer 2 notes that "the textbook frequently encourages reflection and self-assessment," while Reviewer 1 highlights that "the variety of task types and approaches prevents the material from becoming stereotyped."

3.6 Area 6: Learners' Agency

Students' agency in their learning process is limited by the structure and methodology of the material. All three reviews agree that the educational resource follows a fixed structure, leaving little room for significant modifications to the learning process, such as skipping exercises. Most tasks are interconnected, meaning that students need to understand vocabulary from a previous exercise to comprehend the next text. "The structure of the material is clearly defined, which leaves little room for transforming the learning process (for example, by omitting certain tasks). Most activities are interconnected in some way," states Reviewer 2.

On the other hand, group and partner activities allow for creativity and independent thinking, particularly in communication-based exercises and freewriting tasks on specific topics. A significant component that **genuinely enables students to independently manage their learning process** is the "Project" section. In the exercises, students (individually or in groups) take full responsibility for the final output, organizing their entire workflow from planning to execution. However, the reviewers identified **no exercises or text sections that directly encourage critical reflection on learning**: "I did not find any types of tasks that would relate in any way to the critical reflection of the content or the material itself," states Reviewer 3.

The illustrations and photographs demonstrate a clear effort to **depict diversity**. Reviewer 2 and Reviewer 3 state that the images reflect varied communities and avoid stereotypical or discriminatory representations. The texts are neutral, without any signs of racial, religious, or gender discrimination. The topics are presented without bias, focusing on different aspects of students' everyday lives.

Diversity is also evident in the choice of character names and illustrations, suggesting that the textbook includes protagonists of various racial, ethnic, and cultural backgrounds rather than focusing on a single, predefined set of characters. The reviewers agree that the dialogues and stories reflect everyday school life and present a range of social contexts, enhancing the accessibility and relatability of the content for a broad spectrum of students. However, one of the evaluators (Reviewer 1) is more critical. He points out, for example, the absence of the topic of single-parent families or the LGBTQ+ community:

> What I unfortunately didn't find inclusive in either the textbook or the workbook was the way the family is described. There is no mention of the fact that there are single-parent families, which can lead to some children feeling excluded. The only relationships depicted are heterosexual, which I find normative.

Regarding independent learning, Reviewer 3 notes that "in the online version of the textbook, students are not required to complete exercises sequentially—one exercise does not unlock another upon completion." Instead, students can complete activities in any order, allowing them to self-direct their learning and revisit unfinished tasks for further practice.

However, reviewers generally agree that the textbook provides a limited degree of learner control over the learning process, awarding this area only two or three stars out of five.

4 Discussion and Conclusion

The Project 2 English language learning material is part of the "Project" series. It is the second part of a

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multi-level series designed for students at the A1–A2 level of the Common European Framework of Reference for Languages (CEFR). In Czech schools, it is commonly used for teaching students in the 6th and 7th grades of lower secondary school. This corresponds with the current national curriculum, as the expected level of English language proficiency at the end of 9th grade is still set at A2 according to the CEFR. This meta-review focused on the digital version of the textbook, which complements the printed package. The objective was to identify and describe components that meet inclusivity criteria in educational materials and support the learning processes of students with diverse needs.

The textbook covers key areas of foreign language learning, including grammar, vocabulary, listening, reading, writing, and conversation. Lessons are structured into short, well-organized units that facilitate the progressive development of language skills. While the textbook is clearly designed with educational intent, it does not explicitly articulate its pedagogical philosophy or clearly define its target age group beyond the indicated A1/A2 proficiency level.

Philosophy and Design of the Learning Material. All three reviewers agree that the textbook clearly structures the learning material, which contributes to its readability. On the other hand, they all point out the lack of an explicit explanation regarding the book's pedagogical philosophy, target group, and didactic intention. The reviewers also point out that the textbook is not clearly linked to the curriculum documents of the Czech Republic, specifically the Framework Educational Programme (RVP).

Learners' Needs. The learning material allows students to use different learning strategies, particularly when selecting exercises of varying difficulty levels. Some lessons incorporate scaffolding techniques, offering structured learning support based on students' competencies. The textbook includes multiple modes of content representation, such as color illustrations, photo stories and dialogues, video sequences, and audio recordings with transcripts and adjustable playback speed, accommodating diverse student needs. All three reviewers confirm that the material offers a wide range of tasks, supports different language skills (reading, listening, writing, speaking) and allows a multisensory approach (listening, visualization, completion, group and partner work, etc.). All reviewers also confirm the presence of scaffolding elements, such as model sentences, examples of procedures, guiding questions, structured project tasks, or support for working with texts and making statements.

The reviewers explicitly mention firstly the integration of text, listening, and visual elements, secondly the transcripts for audio and video recordings, and thirdly the many pictures and colour illustrations (also available online) as factors that add flexibility to the learning materials and allow them to be adapted to learners' individual needs and preferred learning styles (visual, auditory, practical).

Learners' Environment. The reviewed material comprises the full package, which includes the student's book and workbook (in both print and digital formats), as well as the teacher's guide. The format is designed for use in both physical and digital learning environments. Reviewers are divided on the accessibility of the digital components. Reviewer 1 criticizes the fact that full access to the digital textbook is only available with a paid license, which may exacerbate social inequalities among students and schools. Reviewer 2 points to the limited functionality of the free online version, which does not include transcripts of the audio recordings. Furthermore, the reviewers conclude that the material is primarily intended for individual work, but it also includes some tasks suitable for group activities (e.g., creating dialogues, stories, etc.).

Learning Feedback for Learners. In some lessons, the textbook integrates feedback mechanisms such as answer keys and knowledge-check activities,

which support students in tracking their learning progress. Reviewers have different opinions on how the textbook provides feedback to students. They mainly disagree regarding the feedback mechanisms' effectiveness. Two reviewers note that the "Revision" and "Progress Check" sections of the workbook offer opportunities for feedback and individual reflection. The students can assess what they already know and what they need to focus on. Both reviewers rate this area as useful, but not comprehensive (e.g., lacking formative feedback or reflection based on error work). Reviewer 2 even argues that students' learning progress cannot be monitored through exercises. Overall, the scope and forms of feedback are considered limited by the reviewers, since there are no reflective questions, text feedback, or adaptive elements.

Learners' Reflections on Learning. All reviewers agree that the textbook offers a range of learning strategies and techniques that promote learner engagement and foster independence. These include grammar tasks of varying difficulty, creative and project-based activities, practical language use, communicative tasks, and dramatization. One reviewer highlights the "Project" sections as supporting the use of different learning styles in a positive and engaging way. Another reviewer emphasizes the systematic structure of grammar exercises, while the third focuses on how the material responds to diverse student needs. There is consensus that the material is methodologically well designed and offers a variety of learning strategies. Regarding learners' reflection on their own learning, two reviewers note that there is limited and scattered space for such reflection (e.g., in the "Progress Check" and "Revision" sections). In contrast, the third reviewer states that they did not identify any elements of reflection in either the textbook or the workbook. Thus, in the area of individual reflection, opinions range from critical to moderately supportive of the material's potential to encourage reflective learning.

Learners' Agency. All three reviewers agree that the structure of the textbook is fixed and that learners have only limited opportunities to make decisions about their own progress or to control their learning paths. Only a few sections allow students to adjust aspects of the learning process, such as the pace or their approach to completing tasks. At the same time, there is a lack of opportunities for critical reflection on learning. Reviewers agree that the material does not include tasks that promote metacognitive thinking or self-reflection. Two reviewers state that the material reflects learner diversity, while Reviewer 1 considers the representation of diversity to be insufficient.

Our meta-review of the three included evaluations shows high agreement regarding the assessment of the teaching/learning material. Although the evaluation of the textbook was conducted independently and separately, all three reviewers view the textbook through the same lens. One reason for this may be the precision of the FroLLM grid that was used to guide the review process, which covers the areas under study in great detail. The individual criteria then allow the reviewers to recognize the observed phenomena and their interpretation, thereby reducing the degree of subjectivity. Another reason may be the transparency and systematic construction of English language textbooks as educational materials.

Conducting meta-reviews of the inclusiveness of English language textbooks is an important part of the analysis and evaluation of educational resources. Their importance is further emphasized by the ongoing curricular reform of the Czech education system, which introduces mandatory English language teaching from the first year of primary education beginning in 2027, while increasing the expected level of English proficiency for ninth-grade students. These changes significantly increase the demands on the quality and inclusiveness of educational materials. A textbook that systematically integrates different learning strategies, feedback options, and reflection can significantly support teaching practice in heterogeneous classes. At the same time, the analyses provide valuable information for textbook authors and curriculum developers.

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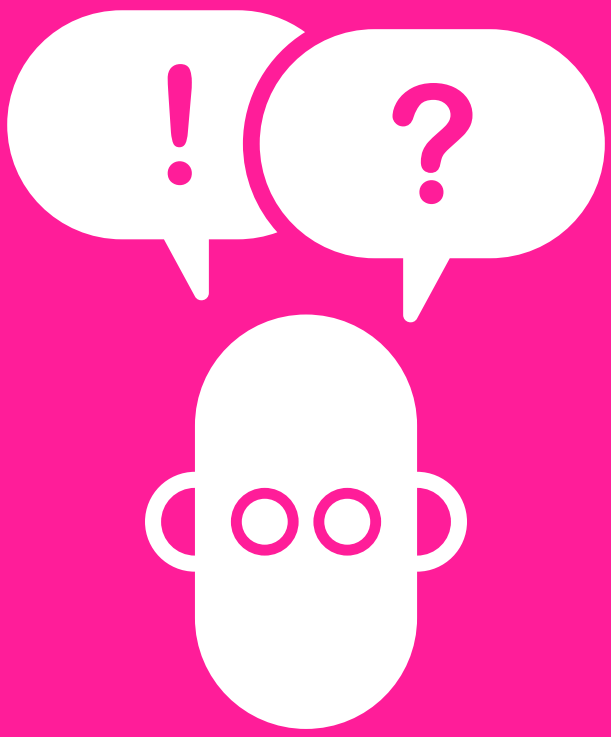

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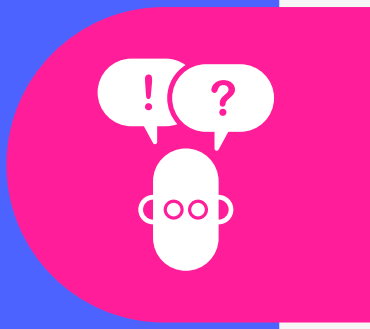

Imaginaries of Openness in Education

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Abstract:

Openness in education is a concept gaining traction in higher education worldwide. Prominent manifestations include Open Educational Resources (OER), Open Educational Practices (OEP), Massive Open Online Courses (MOOCs), and open-source learning management systems (LMS). Governments, organizations, and universities present these as powerful tools to solve pressing problems in education systems. In this essay, I posit that Open Education can be conceptualized as an educational imaginary, a societal vision for the future where technology and education are of significance (Jasanoff & Kim, 2015; Rahm, 2023). Using this heuristic lens, I illustrate three imaginaries of openness to demonstrate why implementations of Open Education might fall short of expectations due to conflicting visions of openness. This essay is not intended to be exhaustive regarding current developments in the field of OER.

Keywords:

Open Education; imaginaries; higher education; Open Educational Resources (OER)

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1 Introduction

Over the past two decades, Open Education has evolved as a field of research and practice comprising multiple, often conflicting approaches. However, the underlying idea is much older, dating back to the Middle Ages. Nevertheless, the proclamation of the Open Education movement as a social movement is a recent development, embedded in a mode of capitalism driven by digital platforms that control access, data, and value creation across markets. This has led to criticism concerning the underlying claims of openness, and triggered discussions about its impact on science and education, in particular its vulnerability for platform capitalism (Mirowski, 2018). In response to the growing power of commercial education providers, open materials such as textbooks have been introduced with the aim of saving taxpayer money in the context of schools. Permission to repurpose content allows OER-based textbooks to be adapted. In practice, however, the adoption of these OER is often limited by a lack of policy and infrastructure.

Moreover, the cultural practices of sharing and reusing OER are impeded by major technology companies. These corporations have established the extraction and commodification of data as the prevailing standard business approach, which has a detrimental effect on Open Education. These effects are now intensified due to the enormous power of generative artificial intelligence (AI), ushering in a new political economy of AI (Verdegem, 2022) with controversial business practices such as "scraping" (Jones, 2024). Yet at the same time, this development has also put the issue of digital public goods back on the political agenda as an alternative (UNESCO, 2024).

1.1 The Self-proclaimed Open Education Movement

A number of key policy documents from supranational organizations and NGOs have contributed to the establishment of OER as both an educational trend and a defining characteristic of 21st-century society (Ossiannilsson et al., 2020). The term was first defined at the *Forum on the Impact of Open Courseware for Higher Education in Developing Countries* (UNESCO, 2002) as "free educational resources, available to all, for consultation and adaptation by users" (p. 24). The forum discussions focused on the MIT OpenCourseWare initiative, which aims to "publish course content for use as a resource" (p. 1), as distinct from MIT's teaching or distance learning activities. Despite participation from the Global South, the project remained westernised, with over 40% of OER coming from North America and Western Europe (UNESCO, 2023).

The *Cape Town Open Education Declaration* (2007) was launched in light of the growing global collection of OER and made a plea for "freedom to use, customise, improve and redistribute educational resources without constraint". Here, OER were presented as a means of making education more accessible and efficient. However, there was no evidence supporting these claims.

The *Paris Declaration on OER* (2012), in turn, intended to raise awareness at policy, governmental, institutional, and user levels. It provided ten recommendations for nation states to promote the production, use, and re-use of OER in education. A closer look at these and other policy documents reveals certain preconditions for OER, such as OER strategies and policies, or capacity building for teachers and institutions. At the same time, another narrative emerged, portraying OER as a key driver of modernization and innovation in education. Open IT infrastructures and digital competencies for teachers and learners are significant for the uptake of Open Education (see the Digital Competence Framework for Educators, DigCompEdu as described by Redecker & Punie, 2017). This can also be seen as an attempt to capitalize on the then-emerging development of commercial platforms, such as Facebook, as a one-stop shop for news and social engagement. The practices of

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modifying and remixing content have become well-established on social media, but not so much in the context of OER. This is because public funding tends to encourage the production of new content or so-called "dark reuse"—a term inspired by the concept of "dark matter" in physics to describe a form of reuse that is not visible or detectable, for example because it takes place outside of repositories or platforms.

In late 2019, UNESCO member states adopted the first international agreement on OER, in which they promote equitable and quality education as well as lifelong learning (UNESCO, 2019). The 2019 document is more comprehensive than the 2012 *Paris Declaration*. For instance, it includes policy frameworks and legislative measures, and it emphasizes monitoring strategies to assess the effectiveness and impact of OER policies and practices.

Based on this brief review of policy documents, it can be concluded that there is a normative core within the Open Education Movement, which makes fundamental claims about the role of (open) education for the future of society. This layer emphasizes Information Communication Technologies (ICT; Kania-Lundholm & Torres, 2018) and education for all, in line with the 1948 *Universal Declaration of Human Rights*. *Openness* (e.g., open science, open innovation) is a social approach to drive systematic change in knowledge-intensive activities such as teaching and learning (Ossiannilsson, 2023).

In what follows, I will outline a critical analysis of the claims made by the Open Education Movement, which was conceived of as a form of grassroots social movement over the last two decades. I will first introduce my conceptual lens before detailing three main visions for which the values of Open Education have been used.

2 Conceptual Lens: Educational Imaginaries

In this methodological section, I suggest that the concept of imaginaries is a valuable heuristic for making sense of the different ambitions attached to Open Education, such as in discourses on OER, and how this relates to digital learning materials. Socio-technical imaginaries (STI) are defined as "collectively held, institutionally stabilised, and publicly performed visions of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology" (Jasanoff & Kim, 2015, p. 4). According to these authors, imaginaries are directed towards both desirable and undesirable futures; furthermore, they are already circulating in the present, foreshadowing future technologies and their effects. Such imaginaries can obscure political choices by naturalizing futures that appear to offer no alternatives. This makes it difficult to critically reflect on existing crises (e.g., social inequality, technological alienation) and develop sustainable alternatives. Moreover, in the aftermath of the widely publicized release of ChatGPT in late 2022, there has been a discernible popularization in the concept of "AI futurism imaginary" (Schütze, 2024). This notion has become pervasive in both corporate and political discourse, characterized by the perception of technologies as a panacea, which serves to perpetuate the prevailing socio-economic order.

Thus, as posited by Gorur et al. (2019), there is an increasing necessity to employ the framework of imaginaries to enhance awareness vis-à-vis pervasive neoliberal governance (e.g., increasing use of market-oriented logics, accountability mechanisms, and technocratic policy instruments). This necessity has been acknowledged in several recent publications, which analyze the role of education in the regulation of technology (Rahm, 2023a, 2023b; Friesen, 2020). For instance, Rahm (2023a) expands the aforementioned

definition of STI by Jasanoff and Kim (2015) to consider "how education is repeatedly used as a governing tool to reach certain future social goals" (p. 9). Using the case of "digital citizenship", Rahm (2023b) also uses STI to show the different ways in which education is used as one of the most central instruments to create the social preconditions necessary for the computerization of societies. Yet, to the best of my knowledge, the imaginaries heuristic has not been explicitly applied in the context of OER.

Drawing on this understanding, I will now present three educational imaginaries that are prominent in discourses on Open Education: (1) education for all, (2) modernization of educational systems and societies, and (3) innovation of teaching and learning practices. All three are derived through a process of review and analysis of key policy documents, as referenced in the preceding section. This approach is informed by sustained engagement with the Open Education Movement, which has yielded numerous publications over an extended period (see for example Deimann & Peters, 2016).

2.1 Education for All

During the 1960s, Open Education was principally administered as a child-centred approach, emphasizing children's active participation in their own learning (Lynch, 1975). Concurrently, it was also part of a broader movement of social upheaval. During this period, the individual learner came to the fore, and participation as well as self-determination in one's own lifelong learning process became a core value. From an organizational point of view, the main objective was to provide access to high-quality education and to remove barriers to entry. The establishment of the Open University of the United Kingdom (OUUK)[1] in 1969 was the poster child for the realization of the broad ambitions of (higher) education for all. Thus, many institutions around the world were quick to follow the UK's approach (Bell & Tight, 1993). In addition, the OUUK is one of the key actors in initiating the educational imaginary of openness for all, i.e., the belief that higher education should not be accessible only to those who can attend classes regularly. By definition, open universities differ from traditional universities in that they offer open admission and open access to their programs. Their core mission has been articulated by the OUUK as three interrelated principles of openness in relation to (1) *people*, i.e., no entry qualifications required, (2) *places*, i.e., learning anywhere and anytime, and (3) *methods*, i.e., teaching concepts designed to meet learners' specific needs. It should be mentioned, however, that at this time there was a debate about whether Open Education approaches should differentiate between students with and without disabilities (Traub et al., 1972), indicating a blind spot in the *Education for All* imaginary. As can be seen in the *Plowden Report* (Blackstone, 1967), while Open Education was concerned with inclusion and the need to adapt teaching methods to different abilities, these attempts were largely concerned with social class and cultural background instead of various types of disability.

In addition to open universities, UNESCO is another key player in promoting education for all. This is evident not only in its efforts to promote the concept of OER, but also in its attempts to remind policymakers of the right to education, which is rooted in the 1948 *Universal Declaration of Human Rights*. In the context of global upheaval caused by World War II and the rise of past and present fascist movements, education emerges as a pivotal means of empowering economically and socially marginalized adults and children, as well as a fundamental prerequisite for all individuals to participate meaningfully in democratic life (Ossiannilsson, 2023).

Historically, financial limitations have hindered progress towards this ambitious objective, highlighting

[1] The idea of establishing an open university, which led to the creation of the OUUK, can be attributed to two key factors: a particular teaching method (distance learning) and a set of supporting technologies (paper, radio, television, digital media).

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the vital role of OER. In public education, the case for educators to share OER can be compelling (e.g., visibility in communities or recognition of open practices). However, expenses such as attribution of freely available materials or copyright clearance are often underestimated. The lack of evidence for the impact of OER on teaching and learning (Santos-Hermosa et al., 2017) and on supporting underprivileged groups specifically is another major obstacle to achieving the ideal of education for all.

2.2 Modernizing Educational Systems and Societies

Since the 1960s, there has been a push to use the openness movement to modernize education systems and even societies. The OUUK is a good example of this. After World War II, Europe was in ruins, and society had to be rebuilt. Modernizing educational institutions was a key part of this. In the UK, the OUUK was predicated on the notion of a "University of the Air," namely the utilization of the British Broadcasting Corporation (BBC) to establish a university accessible to all (Evans & Jakupec, 2023).

Fast forward, to the mid-2010s, when, in a similar attempt, the European Commission initiated "Opening up Education". This program did not explicitly address the fundamental goal of education for all. Instead, it argued that Europe risks lagging behind if it does not invest substantially in ICT for schools and universities (European Commission, 2013). This represents a somewhat classical imaginary, as defined by Jasanoff and Kim (2015), in which technology is considered the primary agent in determining the vision of a desirable future and in proposing appropriate means to innovate education. This standpoint is underpinned by the assertion that "digital technologies are fully embedded in the way people interact, work and trade," which is then used to formulate the seemingly uncontroversial statement "that they are not being fully exploited in education and training systems across Europe" (European Commission, 2013, p. 4).

As for the OUUK, contemporary technologies play a pivotal role in the democratization of education and in the reduction of costs for educational institutions and students. Intriguingly, the predominant technologies are still broadcast-based, delivering content from specific institutions, predominantly from the Western Hemisphere, to audiences worldwide (Qayyum, 2023). The concept of realizing this imaginary became known as Massive Open Online Courses (MOOCs) and came to prominence in the mid-2010s, as indicated by the claim „Year of the MOOC" (Pappano, 2012). It is important to note that this pedagogical approach bears a striking resemblance to the manner in which courses have been delivered by the OUUK since 1969, and so it can be argued that the vision of the future portrayed by MOOCs was in fact less progressive, let alone disruptive, than actors such as the EU claimed. It rather was a continuation of the dominant industrial model developed in the tradition of distance education (Peters, 2004). Moreover, while MOOCs have often been praised for their potential to break down barriers to education by providing access to high-quality university courses for anyone with an internet connection, this is not the case for everyone. Learners with disabilities are often neglected, although there are some supporting initiatives (Fidalgo-Blanco et al., 2016). Research on MOOCs for workforce development recognizes the need to reach populations with limited access to education (Garrido et al., 2016) but tends to focus on socially disadvantaged groups, while accessibility for learners with special educational needs should also be extended.

2.3 Innovating Teaching and Learning Practices

The third and final imaginary of Open Education that will be presented here pertains to the core business of education, teaching and learning, and is also the main target of the OER movement. This is due to the fact that OER provide free access to educational materials and allow users to modify and adapt them according to their needs. Following the initial attempts to

establish OER in broader discourses on widening access to educational institutions, the discourse shifted from (open) content to (open) practices —also referred to as the second phase of the OER movement (Murphy, 2013). It was argued that simply making OER available to learners would not contribute much to the envisioned transformation of education, due to the dominant teacher-centric models (Geser, 2007). In later publications, since the mid-2010s, Open Educational Practices (OEP) have been conceptually decoupled from OER and have also focused on open pedagogies and open technologies (Carey et al., 2015). A more comprehensive framework of Open Educational Practices used during COVID-19 is presented by Huang et al. (2020) and includes OER, open teaching, open collaboration, open assessment, and enabling technologies, such as cloud computing.

Accompanying the shift from merely providing OER to open practices is a growing awareness of educational environments that actively promote participatory, inclusive, and socially just learning for diverse needs, including those of learners with disabilities (Ebner et al., 2022). The integration of assistive technologies is viewed as essential, in particular given the possibilities of AI in education, such as automatic text-to-speech conversion with adjusted reading speed for learners with visual impairments. However, measures such as the creation of open algorithms and the collection of learner data are needed to ensure that AI systems do not exclude learners (Bozkurt, 2023).

With the rise of digital learning platforms and services, there is a growing debate about the importance of digital infrastructures as catalysts for OER and OEP (Heck et al., 2020). Interoperability, metadata, and other intelligent ways of connecting both existing and new solutions are needed to reach a stage of "distributed learning ecosystems" (DLE) that combine local learning management systems with additional teaching and learning tools (Otto & Kerres, 2022). While the concept of DLE focuses on the adoption and discoverability of OER in education, it is also an imaginary because emerging technologies are the leading force in bringing about transformation and progress, i.e., better teaching and learning experiences (Tlili & Burgos, 2022). Scenarios of future learning are therefore deeply enmeshed in issues such as the privacy and security of algorithms, and they depend on the power of machine learning (Markham, 2021).

3 Discussion

As Open Education has gained renewed attention and is increasingly regarded as a tool to address significant educational issues via deep AI integration, a critical analysis of visions and arguments from the last two decades seems warranted. Drawing on almost twenty years of experience in the Open Education Movement, this essay offers an attempt at self-reflection and draws on STIs, particularly sociotechnical and educational imaginaries, to examine some of the movement's core assumptions. Imaginaries highlight interconnections between technologies and visions of the future of education but are in a process of constant (re-)formation, as shown by a review of Open Education.

At the inception of OER in the early 2000s, the prevailing discourse centred on aspirations and pledges that resonated with the imaginaries of early cyberspace proponents (Bory, 2020), particularly concerning the internet's capacity to democratize learning, thereby dismantling conventional barriers pertaining to location, time, and resources. The concept of a digital library and global knowledge networks is congruent with the vision of the internet as an infinite repository of knowledge where individuals can access educational resources. Nevertheless, as emphasized by Chenou (2014) in his review of internet governance debates in the 1990s, capitalist structures that had already become dominant at the time restricted the emancipatory use of the internet and enabled the rise of a transnational power elite, thereby placing the concept of OER in a defensive position, which means that is has to increasingly justify and assert itself.

The cyber-utopian narrative that prevailed among the general public in the late 1990s has since lost some of its appeal, while issues of surveillance, the questionable business practices of technology companies, and right-wing politics have become major concerns (Golumbia, 2024). Nevertheless, the optimism surrounding Open Education remains unabated, particularly in light of the recent surge of interest in generative AI, which is regarded as a catalyst for the digital public good (UNESCO, 2024). Actors such as the Mozilla Foundation (Marda et al., 2024) attempt to frame AI as a transformative force that could foster more inclusive, participatory, and accessible educational ecosystems. The reinvigoration of the notion of a digital public good has served to reinforce the concept of "*Education for All,*" which had previously lagged behind the appeal of the "*Modernization of Education*" imaginary in the mid-2010s. However, a decline in participation has been observed in Massive Open Online Courses (Glass et al., 2016), which were previously lauded for their cost-effectiveness. Coupled with insights gained from the COVID-19 pandemic, with its exhaustive emergency-remote teaching (Ferdig et al., 2020), this has led to a discernment of the limitations of educational technologies as far as their capacity to drive innovation in education is concerned.

From the perspective of Open Educational Practices, there are calls to rethink the teacher-student relationship, with students taking an active role in shaping educational content, methods, and assessments (Brandenburger, 2022). This may lead to a greater appreciation for the role of OER as a way of providing inclusive digital learning materials. Yet, in order to advance towards the mainstreaming of OER as the default standard for the production and distribution of content in teaching and learning, regulatory frameworks that more accurately reflect the current socio-technical landscape are required and should strongly be enforced to prevent powerful market players to undermine governance approaches or implement them in a purely symbolic manner (Litta & Bihr, 2025).

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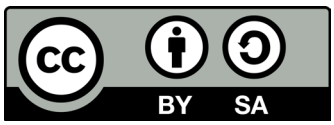

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