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STUDY

FROM POLICY TO PRACTICE: MONITORING SDG TARGETS WITH PIRLS 2021 AUSTRIAN DATA

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ABSTRACT

This study uses the Progress in International Reading Literacy Study (PIRLS) 2021 data to test quality education targets related to primary education achievement, early childhood, skills for work, equity, the learning environment, and teachers' highest levels of qualification. Using Austrian data as a specific case, a regression analysis was performed on items from the student, home, and teacher questionnaires with overall reading literacy achievement as the outcome variable. Results show a drop in Austrian primary education reading literacy achievement between PIRLS 2016 and PIRLS 2021. Targets of early childhood, skills for work, equity, and a safe and effective learning environment are statistically significantly related to reading achievement. Boys trail girls in reading achievement, and higher teacher qualifications do not translate into significantly better reading results. The study's focus on targets with evidence from PIRLS raises two issues: the extent of the PIRLS contribution to measuring and monitoring SDG 4 targets and how PIRLS can help operationalize interconnected targets.

KEYWORDS

International Large-Scale Assessments (ILSAs); Progress in International Reading Literacy Study (PIRLS); Sustainable Development Goals (SDGs); Sustainable Development Goal 4 (SDG 4)

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Introduction

The increasing globalization of education standards and market demands require more focus on the quality of education. According to Tatto and Pippin (2017), it has become a significant and fiercely debated area that cannot be disregarded. "Education is high on the agenda of governments around the globe" (Robinson, 2016, p. 6) as nations move to upgrade teachers and reform teaching to improve their standings on international assessments. The global pursuit of the Sustainable Development Goals (SDGs), led by agencies like the United Nations Development Program (UNDP), aims to reach the SDGs by 2030 and highlights SDG 4 as a pivotal driver in achieving this goal. The 17 SDGs represent goals for social improvement (e.g., hunger, poverty, health, well-being, and reduced inequalities), the environment (e.g., climate action, clean energy, life below water, and life on land), and economic development (e.g., industry, innovation and infrastructure, decent work, and economic growth) (UN, 2015). To gauge evidence of the achievement of the SDGs in the European Union (EU), a systematic literature review conducted by Trane, Marelli, Siragusa, Pollo, and Lombardi (2023) highlighted the rising interest of scholars in operationalizing Agenda 2030. European studies currently devote major interest to environmental concerns (especially linked to SDG 6, 7, 12, 13, and 15), while social issues (e.g., SDG 4, 5, and 10) still warrant more research. While the EU strongly committed itself to the SDGs, clear metrics and data are essential for countries to track progress and achieve these goals. Trane et al. (2023) mentioned, as examples of what has been done in the EU thus far, the "European Sustainable Development Report" (SDSN & IEEP, 2021), which has been monitoring the performance of all EU members, the United Kingdom, partner countries, and the EU as a whole since 2019. The OECD published the "Measuring Distance to SDG Targets" report in 2016, 2017, 2019, and 2022 (OECD, 2022), grouping national trends toward the SDGs. The "Monitoring Report on Progress Towards the SDGs in an EU Context" is published yearly (Eurostat, 2022), with analysis that builds on the EU SDG indicator set, 100 indicators developed in cooperation with a large number of stakeholders for the specific EU context and structured along the 17 SDGs. Finally, "Measuring the Situation of the European Union with regard to the SDGs" (ASviS, 2019) by the Italian Alliance for Sustainable Development tracks the progress of the EU on each SDG by a subset of Eurostat indicators, covering the period from 2010 as a baseline up until 2017.

SDG 4 is crucial in achieving the remaining SDGs (Madalinska-Michalak, 2023; OECD, 2017; Priyadarshini, 2019; UNESCO, 2021; UN, 2018). It significantly empowers individuals to develop knowledge, skills, and values

that promote the SDGs. This idea is supported by the fact that education is recognized as a crucial tool for achieving the SDGs and improving people's capacities to address environmental and development issues. The global community has mandated this recognition, and the UN has emphasized the importance of education since 1992. Several studies, including those conducted by Fehlner (2019), Havea and Mohanty (2020), Kumar (2020), and the OECD (2017), have highlighted the critical role of education in promoting sustainable development. SDG 4 represents quality education, a goal that broadens opportunities across all phases, including primary, secondary education, vocational, higher, and adult education to encompass outcomes of literacy, numeracy, and wider aspirations such as citizenship, sustainability, and gender equality (Bruns et al., 2019; Unterhalter, 2019). This goal was endorsed by Priyadarshini (2019), who stated that education, literacy, and adult learning are key to achieving the SDGs. In summary, SDG 4 is crucial in promoting sustainable development, empowering individuals, and achieving the remaining SDGs by providing quality education.

The concept of quality education (which is also the label for SDG 4) is too complex and multifaceted to define, especially in the field of teacher education research. This view was also held by Flores (2023, p. 32), who stated that "there is no single definition of quality that applies universally nor is there a single recipe for improving quality in initial teacher education programmes." Therefore, this research seeks to explore and define the dimensions of quality education within the context of SDG 4 by investigating the relationships between early home literacy activities, the learning environment, equity considerations, and reading literacy outcomes among ISCED level 2 (i.e. fourth grade) Austrian students, utilizing data from the Progress in International Reading Literacy Study (PIRLS) 2021. For purposes of the current analyses, Austria presents itself as a case of a developed, central European country with a history of PIRLS participation since its 2001 cycle of administration. World Bank figures show that Austria has a total population of 8.9 million inhabitants (World Bank, 2021, as cited in Van Staden & Schreiner, 2023), with an overall student population of approximately 1.1 million children in the 2020/2021 school year (Statistik Austria, 2022). The Gross Domestic Product (GDP) for 2021 is listed as 477.08 billion US dollars in total and 53,267.9 US dollars per capita (World Bank, 2021, as cited in Van Staden & Schreiner, 2023). Depending on the educational track, the government provides up to 13 years of schooling and one additional year of compulsory kindergarten. By examining these factors, this research aims to contribute to a nuanced understanding of how to conceptualize and operationalize quality education, particularly in terms of fostering reading literacy skills and addressing disparities in educational achievement.

First, this paper introduces the SDG targets and their indicators, followed by the applicability of ILSAs and their relation to SDG 4. It then discusses the research questions and methodology, followed by the results, discussion, limitations, and conclusion of the study.

1 SDG 4 targets and indicators

SDG 4 aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (UN, 2015, p. 19). This SDG consists of 10 targets and 12 indicators as suggested by the UN (2015). The first seven targets with indicators are based on the outcomes that are envisioned by the targets, and the last three focus on the means of implementation. Outcome Target 4.1 and Target 4.2 aim to provide unrestricted access to quality education that prepares students for their future education and career paths. While Indicator 4.2.2 includes participation rates, data on these rates are not available in PIRLS. Therefore, the current research does not provide further insight into this indicator. Target 4.3 aims to achieve gender equality through empowering all women and girls, based on equal technical, vocational, and tertiary education access. Target 4.4 focuses on student readiness for the professional world and educational access for marginalized groups. Target 4.5 strives to provide equal access to education for all individuals, regardless of any form of discrimination they may face. This is particularly crucial for those who have been historically marginalized and may encounter further obstacles to education. The objective of Target 4.5 is to promote equal educational opportunities and foster a more equitable society in which everyone can achieve their aspirations. Target 4.6 aims to elevate literacy and numeracy levels across all age groups, including adults and youth. Finally, Target 4.7 emphasizes education on certain content, knowledge, and skills that contribute to sustainable development, human rights, gender equality, and cultures of peace and non-violence.

The last three targets provide the means for executing the quality and equality targets of the first seven (Sayed & Moriarty, 2020). Target 4.a aims at creating effective and inclusive learning environments that are safe and gender sensitive. This target can be achieved by building and upgrading education facilities for children and people with disabilities. Target 4.b aims to increase scholarships for vocational training in information and communications technology (ICT), technical, engineering, and scientific programs. Target 4.c, as an implementation target, aims to increase the number of qualified teachers by supporting underdeveloped countries through international cooperation and other means. Since these targets, together with

their indicators, guide stakeholders in achievement and progress (Moldan & Dahl, 2007), they can also be linked to ILSAs and the achievement of quality education in schools.

2 The role of ILSAs in quality education

The International Association for the Evaluation of Educational Achievement (IEA) develops and conducts ILSAs globally to show student achievement in education systems (Mullis et al., 2023; Leino et al., 2022). ILSAs include IEA studies such as PIRLS (Progress in International Reading Literacy Study), TIMSS (Trends in International Mathematics and Science Study), and the Organization for Economic Cooperation and Development's (OECD) PISA (Program for International Student Assessment) and TALIS (Teaching and Learning International Survey) studies. International assessments are instrumental in monitoring education policies and practices by providing comparative data on educational outcomes and practices across countries; they have been described as the "global yardstick for measuring success in education" (Schleicher, 2017, p. 123 in Ledger et al., 2019). These assessments often inform discussions and decisions regarding education reform and improvement efforts (Mullis et al., 2023). ILSAs are crucial in providing valuable insights into the education systems across countries, facilitating discussions, and shaping policy decisions to improve educational outcomes.

According to Robinson (2016), education is a top priority for governments worldwide, and ILSAs provide valuable evidence to support, monitor, and benchmark educational development. Addey and Sellar (2019) explained that although there was initial skepticism about ILSAs, they have become an essential tool for policymaking over the last two decades. Governments are willing to invest a lot of money in ILSAs because they provide reliable data to evaluate educational outcomes and identify effective policies. Participating in ILSAs demonstrates that a country shares common educational values and goals with other participating nations. Addey and Sellar (2019) developed a four-dimensional framework that outlines the reasons for government participation, including political, economic, technical, and sociocultural rationales.

ILSAs have several rationales that governments utilize for their strategic benefits (Addey & Sellar, 2019). Political rationales involve the use of ILSAs as a tool to navigate domestic policy landscapes, reconcile policy disputes, gain political support, and differentiate political agendas (Addey & Sellar, 2019). The outcomes of ILSAs are often leveraged to instigate policy reforms and shape public narratives around education (Addey & Sellar, 2019;

Waldow, 2017). Economic rationales recognize the link between skill measurements by ILSAs and economic growth, making ILSA results a crucial element for economic strategies (Addey & Sellar, 2019). Technical rationales refer to the methodological rigor and capacity-building potential of ILSAs in educational assessments (Addey & Sellar, 2019). This enables countries to enhance their technical expertise in developing, implementing, and analyzing comprehensive learning evaluations (Addey & Sellar, 2019). Lastly, sociocultural rationales involve the use of ILSAs to align countries with international norms and models for modern statehood. This displays a commitment to modern education systems and policies (Addey & Sellar, 2019).

The use of ILSAs by governments offers a multi-dimensional approach to education policy-making that encompasses political, economic, technical, and sociocultural perspectives. One such ILSA includes the IEA's PIRLS, a global initiative to improve reading, teaching, and learning. Since its establishment in the early 2000s, PIRLS has been administered every five years to assess children's reading comprehension following four years of formal education (Mullis, et al., 2012).

PIRLS assesses the reading literacy of fourth-grade students using two main types of reading tasks and four comprehension methods that evaluate student reading ability in traditional and online formats (Mullis & Martin, 2019). The evaluation focuses on each type of reading task and comprehension method, breaking down what portion of the test is dedicated to each aspect (Mullis & Martin, 2019). The purposes for reading include literary experience and acquiring and using information; the processes include focusing on and retrieving explicitly stated information, making straightforward inferences, interpreting and integrating ideas and information, and evaluating and analyzing content and textual elements (Mullis & Martin, 2019). PIRLS thoroughly and comprehensively assesses student reading literacy and reflects the complexity of reading skills which are essential everywhere.

3 The systemic interconnectedness of PIRLS in relation to SDG 4 targets

The PIRLS 2021 assessment framework recognizes the impact of both student achievement and contextual background factors on the learning environment (Mullis & Martin, 2019). Figure 1 presents the PIRLS 2021 assessment framework. It acknowledges the interplay between student achievement (as an important outcome of quality education) and contextual background factors that shape the learning environment. Figure 1 illustrates this interconnectedness as follows:

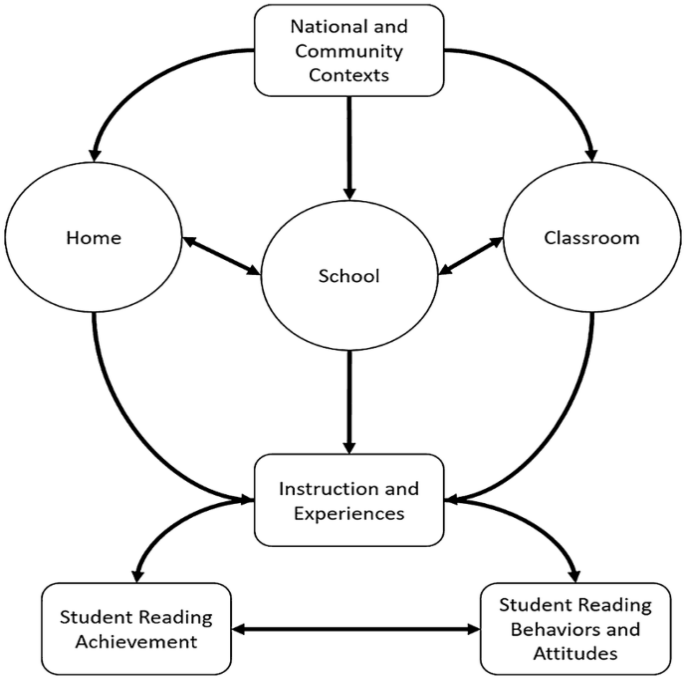

Figure 1
PIRLS 2021 assessment framework Mullis et al. (2012, p. 35)

The assessment framework in Figure 1 further illustrates the interconnected nature of student reading achievement (literacy) as well as their reading behaviors and attitudes towards reading, considering different contexts in which reading takes place, including the home, school, and classroom within national and community contexts. While this assessment framework refers to the work of Mullis et al., dating back to 2012, the tenets and design of this framework remain the same for PIRLS studies in consequent cycles in 2016 and 2021. The framework depicted above, illustrating the complex relationship between student reading achievements and their attitudes towards reading across various contexts, serves as a compelling entry point to discuss the broader interconnectedness of SDG 4 targets and the SDGs, emphasizing the foundational role of literacy as an outcome as one dimension of achieving comprehensive educational and developmental outcomes (Priyadarshini, 2019). Figure 2 illustrates how SDGs are linked to one another.

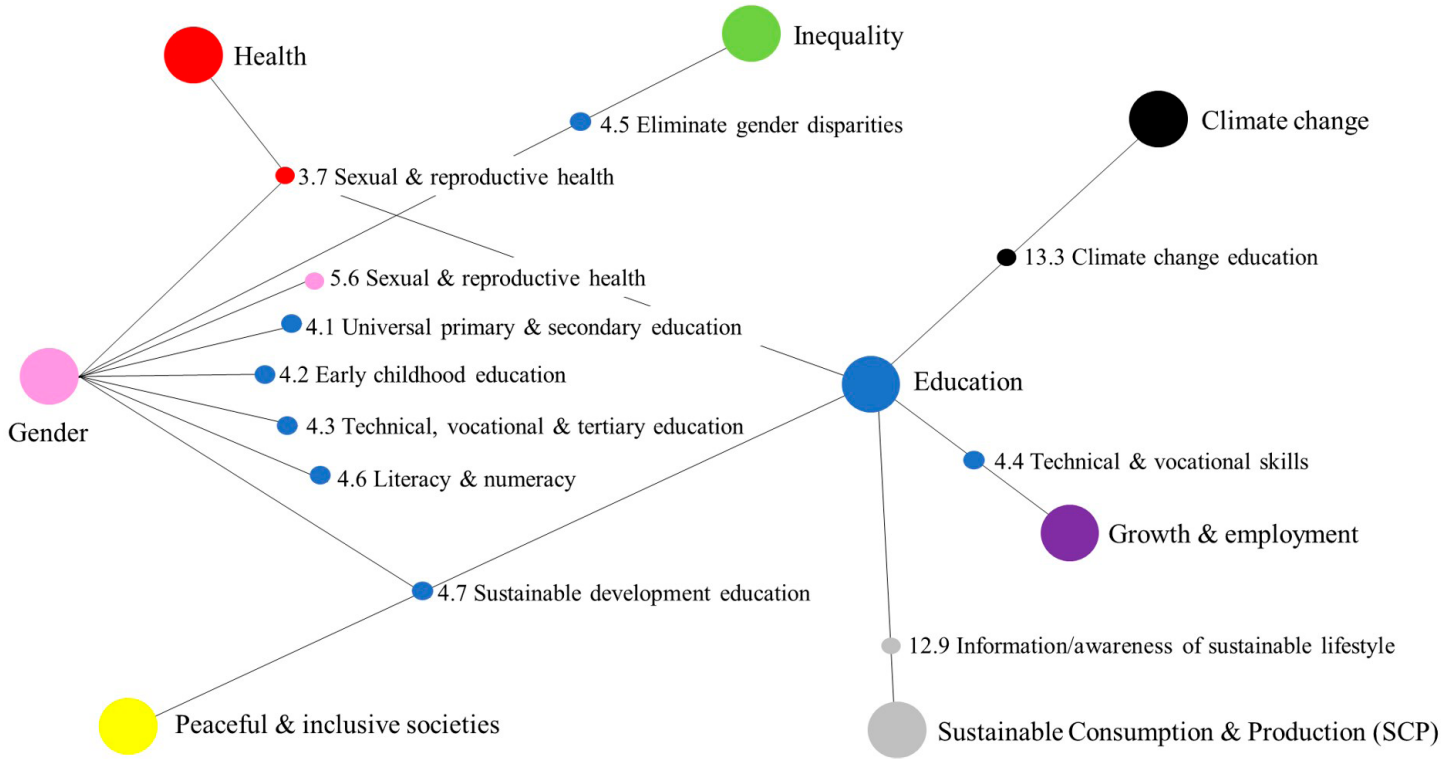

Figure 2

The links between education and other SDG targets

Thaung (2018, p. 17)

Figure 2 shows the centrality of education by linking it to different SDGs. The figure shows the links between education, gender, and overall equality, based on Targets 4.1, 4.2, 4.3, 4.5, 4.6, and 4.7 which are present in the quality education SDG but also concerns equality which links it to the other equality SDGs such as SDGs 5, 8, 10, 11, and 16. Target 4.4 links education with growth and employment. This diagram is selected to show how interconnected the SDGs are and the significance of the role SDG 4 plays in Agenda 2030 (also according to Grobler & Dittrich, 2024; Madalinska-Michalak, 2023; OECD, 2017; Thangeda et al., 2016; UNESCO, 2023; UN, 2018). Thaung (2018) highlighted the deep links between education (central to SDG 4) and other key areas like health (SDG 3), climate action (SDG 13), and inclusive and peaceful societies (SDG 16). These interconnections underscore the multifaceted role of education in promoting health, gender equality, environmental awareness, economic skills, and inclusive and peaceful societies, further emphasizing education's pivotal role in achieving the SDGs (Thaung, 2018).

Education in itself has many outcomes, one of which is literacy. Priyadarshini (2019) supports the idea that literacy has a positive impact on both social and economic aspects of an individual life and plays a significant role in the development of communities and nations. Insufficient literacy can significantly hinder an individual's involvement in the lifelong learning process, which is crucial for their growth and development (Priyadarshini, 2019). Literacy is not viewed as an enabler but rather an outcome in this study, since the SDG 4 targets can be viewed as essential preconditions for literacy. For instance, early childhood development (Target 4.2) is widely recognized as foundational for later literacy, as early cognitive and socio-emotional support improves children's readiness for learning to read and write (UNESCO, 2015).

Teachers play a crucial role in providing quality education, which makes Target 4.c important in supporting the other SDGs and SDG 4 targets. According to UNESCO (2017), SDG 4 is directly linked to SDG Targets 3.7, 5.6, 8.6, 12.8, and 13.3 through education relations. UNESCO (2017) has also emphasized the urgency of Target 4.c, stating that "teachers are the key to achieving all the SDG targets" (p. 15). This target is essential in emphasizing the importance of quality education in achieving the SDGs. Given its direct impact on achieving other SDGs and SDG 4 targets, the significance of Target 4.c cannot be overstated. Therefore, it is essential to address the urgent need to increase the supply of qualified teachers to ensure quality education for everyone.

The targets and indicators guide the progress and achievement of SDG 4 worldwide. The indicators are useful tools to manage important dimensions of the environment and society (Dahl, 2012). These indicators can be related to early home literacy activities, the learning environment, equity considerations,

and their impact on reading literacy outcomes, tying them back to the specific targets and indicators of SDG 4. Quality education as a goal comprises several targets; in operationalizing these targets, PIRLS can be instrumental in tracking and monitoring performance and mobilizing the associated metrics that better depict the key tenets of the goal (IEA, 2021). These include:

3.1 Primary education (Target 4.1)

By employing international benchmarks, PIRLS can provide diagnostic evidence of children's reading comprehension skills and abilities when they reach the fourth year of primary school, which translates to fourth grade in most countries (IEA, 2016). PIRLS uses four benchmarks: achievement at the Low International Benchmark, where students are only able to achieve at or below 400 score points; the Intermediate International Benchmark, with achievement at 475 score points; the High International Benchmark, with achievement at 550 score points, and the Advanced International Benchmark, with achievement at or above 625 score points (Mullis et al., 2017). In this study, the PIRLS 2021 international benchmark evidence for Austrian fourth-grade students is reported from two perspectives of the quality of primary education: the international median and trends from PIRLS 2016 as evidence of progress or decline.

3.2 Early childhood (Target 4.2)

In recent years, the importance of attending pre-primary school has gained momentum. The PIRLS Learning to Read Survey (or Parent Questionnaire) assesses the availability of these kinds of facilities but also interrogates the kinds of early reading activities at home that parents offer their children (IEA, 2016). The target focuses on both access to and completion of schooling, with indicators that emphasize literacy in reading and mathematics (UN, 2015). The study, however, only focuses on reading literacy through the analysis of PIRLS.

3.3 Skills for work (Target 4.4)

In addition to PIRLS, other large-scale international assessment results consistently show a gender difference for boys and girls in literacy, numeracy, and science, as evidenced by the Trends in International Mathematics and Science Study (TIMSS). PIRLS data highlight the need for systemic intervention to ensure equitable skills for work and also point to differences in exposure to digital resources and technology, ensuring relevant work skills for different labor market contexts (IEA, 2016). One argument can be that digital skills development fosters critical thinking and literacy in digital contexts, which are increasingly part of literacy (e.g., digital literacy) (Kong, 2014).

3.4 Equity (Target 4.5)

PIRLS allows for greater disaggregation of data to provide essential evidence for targeted intervention, monitoring, and planning for crucial sub-groups of the population who may be at a continued educational disadvantage (IEA, 2016). Equity targets for which data is collected by PIRLS include gender, language (for the current analyses, interpreted as the language most frequently spoken at home), and home socioeconomic status. Socioeconomic equity (e.g., access to resources, language spoken at home) affects literacy (Hemmerechts et al., 2017).

3.5 Learning environment (Target 4.a)

PIRLS provides information on the quality of the learning environment in terms of bullying, school safety, and factors that impede teaching practice. Student questionnaires gauge attitudes, opinions, and instances of bullying and the severity thereof, as bullying may not only be a hindrance to academic performance and well-being in the early years but may well continue into secondary school and phases beyond the initial grades when firm foundations in a climate of safety and orderliness are of great importance. Teacher questionnaires gather information about school safety issues and associated factors that severely affect teacher ability to deliver the curriculum effectively (IEA, 2016). A safe and supportive learning environment can impact literacy outcomes by reducing distractions like bullying and creating conditions conducive to learning (Darling-Hammond & Cook-Harvey, 2018; De Nobile et al., 2017).

3.6 Teachers (Target 4.c)

The supply of a qualified teacher workforce is crucial for every education system. While a universally accepted definition of a qualified teacher cannot be applied across contexts and participating countries, PIRLS provides information on the highest levels of qualification obtained for each country (IEA, 2016). While formal qualifications provide some indication of who is needed in front of the classroom to ensure success, other indicators of pedagogical training (such as classroom language, reading pedagogy, reading theory, and assessment methods) refine the outcomes that are obtained over and above formal qualifications as the sole indicator of quality. Teacher qualifications might (or might not) influence literacy outcomes (Guo et al., 2012).

The PIRLS 2021 Assessment Framework is crucial in understanding literacy in relation to SDG 4 and exploring the connections between literacy and other educational goals. It serves as a reference point for investigating these intersections, leading to the research questions discussed next.

4 Research questions

Since Targets 4.2, 4.4, 4.5, 4.a, and 4.c are directly linked to the items in the PIRLS 2021 questionnaire and are plausible predictors of literacy (Target 4.1), the current study aims to investigate the extent of PIRLS 2021 evidence in operationalizing SDG 4 targets and indicators by asking the following questions:

1. What do overall benchmark achievements indicate about the state of primary education in Austria as measured by PIRLS 2021?
2. To what extent do early home literacy activities, as part of Target 4.2, shape reading literacy outcomes?
3. How does exposure to digital resources and technology, as part of skills for work in Target 4.4, affect reading achievement?
4. What role does equity (Target 4.5) play when home socioeconomic factors, language spoken at home, and gender are included as predictors of fourth-grade Austrian students' reading literacy achievement?
5. How are learning environments (in terms of bullying, safe and orderly schools, and factors that limit teacher practice) (Target 4.a) and teachers' highest levels of qualification (Target 4.c) related to reading literacy outcomes?
6. How are results from ILSAs meaningful for SDG 4 targets and indicators in expanding the understanding of these in interconnected ways?

The research questions enable a thorough analysis by evaluating various aspects such as direct measures of academic achievement, contextual factors that impact learning, and the alignment of the findings with the global educational goals set by SDG 4. Further discussion on how this analysis will be conducted is explained below.

5 Methods

5.1 Design

This study takes the form of a secondary analysis of PIRLS 2021 using Austrian data. As a developed country in central Europe, Austrian participation in PIRLS dates back to its first participation in the study in the 2001 cycle. PIRLS is administered to children in their fourth year of schooling. PIRLS 2021 placed Austrian fourth-grade student achievement at 530 (SE = 2.2), a score substantially above the PIRLS scale center point of 500. While these overall results for Austria are encouraging, there was a drop of 11 score points between PIRLS 2016 and PIRLS 2021. This decline may be due to the effects of COVID-19, since PIRLS 2021 was administered amid the school disruption and closure of the pandemic.

PIRLS 2021 consists of fourth-grade achievement data and contextual background data collected from school principals, fourth-grade teachers, and the parents (or primary caregivers) of fourth-grade students. When using teacher and parent data, results are reported regarding the teachers or parents of fourth-grade students since the results are representative at the student level, not the teacher or parent level.

5.2 Sample

A total of 160 Austrian schools participated in PIRLS 2021, and 4,806 fourth-grade students were assessed. From the sampled classes, 305 teachers completed the Teacher Questionnaire and 4,806 parents of fourth-grade students completed the Parent Questionnaire (referred to as the Learning to Read Survey).

5.3 Data collection

Target 4.1 aims to promote fair and just education outcomes by measuring the percentage of children and adolescents who achieve a particular level of proficiency in fundamental subjects at key educational milestones. Specifically, this target assesses student proficiency in reading, writing, and math (a) during the early grades, (b) after completing primary education, and (c) at the end of lower secondary education, with a detailed gender breakdown. This approach concentrates on significant stages in educational development, evaluating foundational learning that can pave the way for future academic success (Indicator 4.1.1). PIRLS 2021 tested fourth-grade student achievement using plausible values on four proficiency scales, namely the Low International Benchmark, the Intermediate International Benchmark, the High International Benchmark, and the Advanced International Benchmark. To provide evidence for research question 1, the PIRLS 2021 overall achievement is used to indicate reading achievement for fourth graders on each of the international benchmarks and also by gender. Since PIRLS does not provide data regarding completion rates, Indicator 4.1.2 was excluded from the analysis in the current study.

To address research questions 2, 3, 4, and 5, reading achievement data in the form of overall plausible values from fourth-grade students were used in conjunction with contextual background data from the Teacher and Parent Questionnaires. These questionnaires were administered to provide a comprehensive understanding of the factors that shape reading literacy outcomes in relation to several SDG 4 targets. Composite scales by means of sum scores were devised for each of the SDG 4 targets. The direction of these scales was all computed to mean that the higher the value, the more of a particular activity or characteristic was present.

Table 1 illustrates the composition of the SDG target scales using PIRLS 2021 contextual background variables to answer research question 2, which asked the extent to which early home literacy activities shape reading literacy outcomes.

Table 1
Target 4.2 – Early childhood and PIRLS 2021 variable composition

Target	Question wording in the PIRLS Early Learning Survey (Parent) Questionnaire	Variable name
Target 4.2: Early childhood	Did your child attend pre-primary school? Yes/No	ASBH05AB
	Before your child began primary/elementary school, how often did you or someone else in your home do the following activities with him or her? Often, Sometimes, Never or almost never a) Read books b) Tell stories c) Sing songs d) Play with alphabet toys (e.g., blocks with letters of the alphabet) e) Talk about things you had done f) Talk about what you had read g) Play word games h) Write letters or words i) Read aloud signs and labels	ASBH01A-I (ASBHELA: Early Literacy Activities scale)

Research question 3 asked about how exposure to digital resources and technology, as part of skills for work in Target 4.4, affects reading achievement. Table 2 indicates the variables used for measuring Target 4.4.

Table 2
Target 4.4 – Skills for work and PIRLS 2021 variable composition

Target 4.4: Skills for work	How much do you agree with these statements about using computers, tablets, or smartphones? a) I am good at using a computer or tablet b) I am good at typing c) It is easy for me to find information on the internet d) I know how to create written stories or reports e) I know how to create presentations f) I can recognize a website that is useful to me g) I can tell if a website is trustworthy h) I know how to make and share a video	ASBG09A-H (ASBGSEC: Digital self-efficacy scale)
	Question wording in the PIRLS Teacher and Student Questionnaire	Variable name
Target 4.4: Differences in exposure to digital resources and technology	What access do the students have to digital devices? Yes/No a) The school provides each student with a digital device b) The class has digital devices that students can share c) The school has digital devices that the class can use sometimes d) Students bring their own digital devices	ATBR12B

Target 4.5 deals with issues of gender, home socioeconomic status, and language. Table 3 indicates how scales for this target were devised in relation to research question 4.

Table 3
Target 4.5 – Equity and PIRLS 2021 variable composition

	Question wording in the PIRLS Student and Parent Questionnaire	Variable name
Target 4.5: Equity	Which best describes you? Girl Boy	ITSEX
	About how many books are there in your home? (Do not count e-books, magazines, newspapers, or children's books.) 0–10 11–25 26–100 101–200 More than 200 About how many children's books are there in your home? (Do not count children's e-books, magazines, or schoolbooks.) 0–10 11–25 26–50 51–100 More than 100 Do you have any of these things in your home? a) Access to the internet b) A computer, tablet, or e-reader c) A smartphone Highest level of education of either parent: Finished some primary or lower secondary or did not go to school 2) Finished lower secondary 3) Finished upper secondary 4) Finished post-secondary education 5) Finished university or higher Highest level of occupation of either parent: Has never worked outside the home for pay, general laborer, or semi-professional (skilled agricultural or fishery worker, craft or trade worker, plant or machine operator), 2) Clerical (clerk or service or sales worker), 3) Small business owner, 4) Professional (corporate manager or senior official, professional, or technician or associate professional)	ASBH12 (ASBHSES: Home Resources for Learning scale) ASBH13 ASDHEDUP ASDHOCCP
	How often do you speak German at home? Always, Almost always, Sometimes, Never	ASBH04

To answer research question 5 of the current study, students and teachers were asked about the extent to which the learning environment (in terms of bullying, safe and orderly schools, and factors that limit teacher practice) and teachers' highest levels of qualification are related to reading literacy outcomes. Target 4.a is operationalized in Table 4.

Table 4
Target 4.a – Learning environment and PIRLS 2021 variable composition

	Question wording in the PIRLS Student and Teacher Questionnaire	Variable name
Target 4.a: Learning environment	During this year, how often have other students from your school done any of the following things to you, including through texting or the internet? a) Made fun of me or called me names. b) Left me out of their games or activities. c) Spread lies about me. d) Stole something from me. e) Damaged something of mine on purpose. f) Hit or hurt me (e.g., shoving, hitting, kicking). g) Made me do things I didn't want to do. h) Sent me nasty or hurtful messages online. i) Shared nasty or hurtful information about me online. j) Threatened me.	ASBG11A-J (ASBGSB: Student Bullying scale)
	Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements: a) This school is located in a safe neighborhood. b) I feel safe at this school. c) This school's security policies and practices are sufficient. d) The students behave in an orderly manner. e) The students are respectful of the teachers. f) The students respect school property. g) This school has clear rules about student conduct. h) This school's rules are enforced in a fair and consistent manner. i) The students are respectful of each other,	ATBG11A-I (ATBGSOS: Safe and Orderly School scale)
	In your view, to what extent do the following limit how you teach this class? a) Students lacking prerequisite knowledge or skills b) Students suffering from lack of basic nutrition c) Students suffering from not enough sleep d) Students absent from class e) Disruptive students f) Uninterested students g) Students with mental, emotional, or psychological impairment h) Students needing extra support in reading	ATBR03A-H (ATBGSLI: Classroom Teaching Limited by Students Not Ready for Instruction scale)

Lastly, Target 4.c, which deals with teacher qualifications, was operationalized by the PIRLS 2021 Teacher Questionnaire data that asked teachers about their highest level of formal qualification. Table 5 indicates the response options for teachers' highest levels of qualification.

Table 5
Target 4.c – Teachers and PIRLS 2021 variable composition

	Question wording in the PIRLS Teacher Questionnaire	Variable name
Target 4c: Teachers	What is the highest level of formal education you have completed? Did not complete/Upper secondary education – ISCED level 3 Upper secondary education – ISCED level 3 Post-secondary/non-tertiary education – ISCED Level 4 Short-cycle tertiary education – ISCED Level 5 Bachelor's degree or equivalent level – ISCED Level 6 Master's degree or equivalent level – ISCED level 7 Doctoral degree or equivalent level – ISCED level 8	ATBG04

After collecting data from PIRLS 2021 and SDG 4 targets (UN, 2015), we utilized quantitative techniques to extract meaningful insights and patterns from the dataset.

5.4 Data analysis

All data were analyzed using the International Database (IDB) Analyzer, which is software specifically developed to analyze large-scale international data with SPPS as the operating platform. To answer research question 1, the overall benchmark results for Austrian fourth-grade children are presented as reported in the PIRLS 2021 International Report (see Mullis et al., 2023). To address research questions 2–5, linear regression was performed on data from the parent, teacher, and student background questionnaires to determine the extent of the possible effect of a number of scales on overall fourth-grade Austrian reading achievement.

6 Results

PIRLS 2021 provides reading achievement results for each of the four international benchmarks. These benchmarks represent four levels of reading competence. Figure 3 illustrates the differences between the international median for PIRLS 2021 International Benchmarks and the Austrian fourth-grade student benchmark achievement:

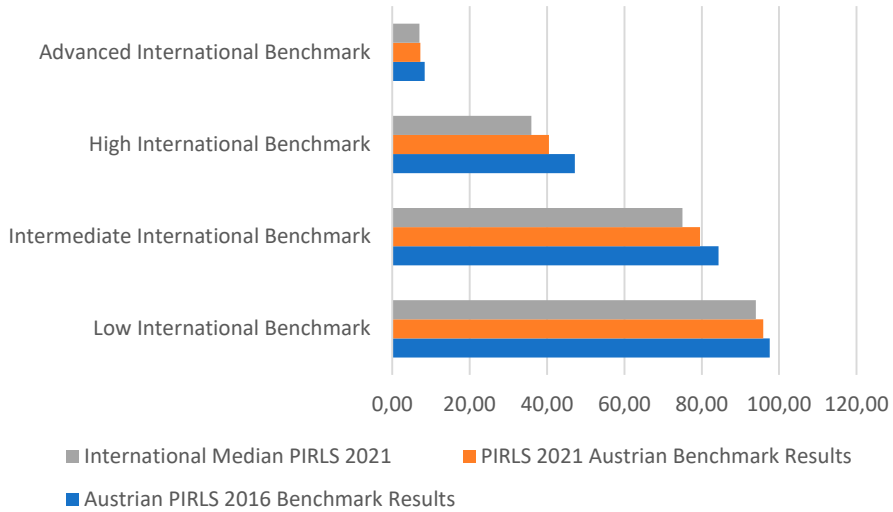

Figure 3
International Benchmarks and the Austrian fourth-grade student benchmark achievement in PIRLS 2016 and PIRLS 2021.

Austrian fourth-grade achievement (represented in Figure 3by the orange bars for PIRLS 2016 and blue bars for PIRLS 2021) at the Advanced International Benchmark resembles percentages of students internationally who were able to reach this benchmark (as indicated by the gray bar in Figure 3). Higher percentages of Austrian students were able to reach the high, intermediate, and low benchmarks, respectively, than their international counterparts. While these signals are good indicators of the Austrian education system, PIRLS 2021 results have shown a slight decrease from PIRLS 2016 benchmark results (Mullis et al., 2017). The effects of COVID-19 could have played a significant role in these decreases, as can be seen from overall trend results from other European countries: France and Turkey showed increases in reading achievement between PIRLS 2016 and PIRLS 2021; decreases were found for Belgium (from 497 to 494 score points), Denmark (from 547 to 539 score points), Germany (from 537 to 524 score points), and Italy (from 548 to 537 score points) among others (Mullis et al., 2023). Nonetheless, Austrian fourth-grade benchmark achievement was maintained at and above the international median in PIRLS 2021 despite overall trend score decreases.

Table 6
Regression results

	b	*SE* B	*t*
(CONSTANT)	188.33	19.5	
Target 4.2 Early childhood development	1.7	0.7	4.4
Target 4.4 Skills for work	1.5	0.7	2.1
Target 4.5 Equity	14.0	0.5	28.1
Target 4.a Learning environment	2.9	0.4	6.8
Target 4.c Highest level of qualification	0.2	4.6	0.5

Table 6 provides the results of the regression analysis for SDG targets that are specifically addressed by the PIRLS 2021 data. The current model explains 32% of the variance in the data, with reliable scales constructed for early childhood development (0.71), and skills for work as measured by the digital self-efficacy scale (0.75). Items that measure exposure to digital devices (see Table 2) were removed from the analysis due to low reliability coefficients. Cronbach's alpha values for the Learning Environment – bullying (0.87), school safety (0.85), and classroom environment (0.76) – were all within acceptable ranges. Home socioeconomic status, as part of the equity target, is a formative construct; calculation of Cronbach's alpha is conceptually meaningless (Stadler et al., 2021).

Of statistical significance in relation to overall reading achievement were those targets related to early childhood development, skills for work equity. and the learning environment, with t-values larger than 1.96 at the 0.05 level of significance. Good early childhood practices seem to make a substantial difference: 97% (*SE* = 0.3) of children who attended pre-primary schools (of whom approximately 80% attended for three years or more) and had parents who engaged in early literacy activities clearly benefited. More than two-thirds of parents of fourth-grade students reported that they often engage their children in reading books, talking about what they had done, counting things, playing games with shapes, and using building blocks. There seems to be room for improvement: 61.5% (*SE* = 0.9) of parents of fourth-grade students reported that their children could not complete early literacy tasks very well. These tasks included recognizing letters of the alphabet, reading some words, sentences, and a story, as well as writing letters of the alphabet and some words. Where literacy activities could be translated into tasks, the expectation may be that the effect on reading literacy achievement might be bigger.

Children's digital self-efficacy as a proxy for skills at work shows a significant effect on reading achievement for the majority of fourth-grade students who indicated high (39.4%, *SE* = 1.0) and moderate (47.5%, *SE* = 1.0) digital self-efficacy.

Equity has a substantial effect of 14.0 score points more in those environments of higher home socioeconomic status, which is true for more than three-quarters of the parents of fourth-grade Austrian students who participated in PIRLS 2021. Gender as part of the equity target provides statistically significant evidence that boys still trail behind girls by as much as 9.8 score points in overall reading achievement. For 74.4% (*SE* = 0.9) of Austrian students, German is most often spoken at home.

A positive learning environment is statistically significantly associated with reading literacy achievement as indicated by 61.2% (*SE* = 1.0) of fourth-grade students who reported that they had never been bullied. A majority of teachers experience the learning environment as very safe (51.63%, *SE* = 3.2) or somewhat safe (47.81%, *SE* = 3.2); their assessment of their teaching being limited by students who are not ready was as low as 2.5% (*SE* = 1.0). While questions to teachers about access to digital devices did not form a psychometrically sound scale, overall descriptive statistics show that the difference between teachers of fourth-grade students who reportedly use a variety of digital devices in a range of ways only once a week (39.2%, *SE* = 3.5) is negligible and one score point higher when compared to those teachers of fourth-grade students who reportedly use these devices every day or almost every day (60.8%, *SE* = 3.5).

Lastly, while not statistically significant, it is interesting to note that teachers' formal qualifications do not show a linear relationship with overall reading achievement. Achievement for students whose teachers have Master's degrees can be expected to be higher by only 0.2 (SE04.9) points.

7 Discussion

The findings of PIRLS Austria 2021, as used in the current research, hold significant meaning for quality education as it can help support the political, economic, technical, and sociocultural aspects (Addey & Sellar, 2019). Developing reading literacy is crucial for an individual's involvement in the lifelong learning process, which supports the social and economic aspects of their life and plays a significant role in developing communities and nations (Priyadarshini, 2019). This study shows how SDG 4 targets are interconnected with each other and PIRLS data, as discussed in the following paragraphs.

Reading achievement results by the international benchmarks for PIRLS 2016 and PIRLS 2021 in Austria provided evidence that minimum reading proficiency levels are on track. While PIRLS benchmark results have shown a slight decrease between PIRLS 2016 and PIRLS 2021, Austrian fourth-grade benchmark achievement was maintained at and above the international median in PIRLS 2021. This study revealed a gender gap

in reading achievement, with boys' reading achievement falling substantially behind that of girls. This evidence highlights the need for equity-focused educational interventions to address such disparities and the essence of Indicator 4.5.1 regarding parity indices focusing on how boys could be empowered to improve their reading skills. Target 4.5 aims to eliminate gender disparities and ensure that everyone, including vulnerable populations, has equal access to education (UN, 2015).

The regression results (Table 6) highlight the importance of digital self-efficacy, early childhood education, a safe learning environment, and addressing equity concerns through a more comprehensive assessment of home socioeconomic factors. These results indicate the essence of aiming to achieve SDG 4 Targets 4.2 (equity in early childhood education), 4.5 (eliminating gender disparities), and 4a (having a safe learning environment) (UN, 2015). These targets are also related to the results in overall reading achievement, which also indicate a direct link to Targets 4.2, 4.5 and 4.a.

Early childhood findings highlight the fact that children who attended pre-primary school for three years or more and engaged in early literacy activities with their parents significantly show the importance of quality early childhood education. However, the attainment of certain early literacy tasks (e.g., recognizing letters of the alphabet), could enhance the role of the early education environment in addition to the role played by activities of interaction and play. This finding aligns with Target 4.2, which seeks to ensure access to quality early childhood development, care, and pre-primary education to prepare children for primary school in fair and equitable ways. When children feel respected and valued in their environment, they are more likely to thrive and reach their full potential (Banks, 2023).

Home socioeconomic status and frequently speaking the test language at home significantly affect reading scores. Research by Hemmerechts et al. (2017) and Beeharry (2021) highlighted the significant gaps in education and literacy, particularly in low-income countries where parental literacy involvement varies across socioeconomic status levels. The study by Van Staden, Bosker, and Bergbauer (2016) on prePIRLS 2011 South African data revealed that African children are significantly disadvantaged if they lack a strong foundation in their native language and receive education in a non-native language during their first three years of school. Exposure to a language that is at least similar to the home language can boost a child's reading performance (Van Staden et al., 2016), thereby highlighting the significance of speaking and being familiar with the language of the test at home to achieve better results.

The current research includes those aspects of the social learning environment at school in terms of safety and bullying. The fourth target's focus on safe, non-violent, inclusive, and effective learning environments

also includes the role of the home environment in education, particularly for early childhood learning (UN, 2015). This statement implies that learning environments are not limited to school premises. It is indeed essential to focus on learning environments in the school, but a broader goal has to be achieved in ensuring a safe learning environment overall, linking this finding to SDG 11: making cities and human settlements inclusive, safe, resilient, and sustainable.

The findings regarding digital self-efficacy speak to practically implementable interventions from as early as possible to ensure that children develop and hone their digital skills in anticipation of the world of work. Target 4.4 of the education agenda is closely related to skills for work and the use of digital resources. Positive digital self-efficacy from as early as possible points to the importance of introducing early interventions when these skills are not developing along a trajectory that would ensure adequate digital readiness for the world of work. Descriptive results show that there were no significant differences in reading achievement based on the frequency of digital device use by teachers. This finding might suggest that digital resources are not important for education. However, this finding highlights the need for a more nuanced understanding of how digital tools are integrated into learning.

These findings suggest that simply increasing access to digital devices, as aimed at in Target 4.4, may not be sufficient. Effective technology integration in education requires quality digital content, pedagogical strategies, and teacher training to improve educational outcomes (Eden et al., 2024). Kong (2014) showed how activities like accessing digital resources, processing information, and engaging in peer discussions improved student ability to critically analyze and synthesize information. SDG 9, which aims to increase access to technology, including (ICT), and to strive for universal and affordable internet access in the least developed countries by 2020 is only realistic when early literacy and skills regarding technology at the school level can be leveraged as tools for effective learning (Neumann, 2018; Paul et al., 2023; Sarker et al., 2019).

In pursuing quality education and lifelong learning for all, the impact of teacher qualifications on student achievement has been a subject of much debate and discussion (Antony & Elangkumaran, 2020). Although not statistically significant, evidence from this study suggests that having higher formal qualifications is not associated with higher reading achievement among students. While teacher formal qualifications are a basic indicator of quality that could be expected, other factors such as teacher attitude, motivation, self-efficacy teaching methods, interactions between teachers and students, and the learning environment may significantly influence student outcomes (Darling-Hammond & Cook-Harvey, 2018; De Nobile et al., 2017; Guo et al., 2012; Osman & Warner, 2020). This observation underlines the need for

a more comprehensive approach to teacher development, which would involve formal education and professional growth opportunities that improve teacher ability to engage and motivate students effectively.

The findings from the current study confirm that PIRLS provides valuable measures for monitoring and operationalizing the SDG 4 targets. Moreover, the current study's contribution and value extend beyond confirming correlations and statistically significant associations: they also indicate that SDG 4 targets are interconnected with one another and that ILSA data (as illustrated here by using PIRLS 2021 Austrian data) provide essential conceptual and empirical basis from which these conclusions are drawn. SDG 4 and its targets do not function in isolation from other SDGs. Therefore, the approach to reaching SDG targets should bear in mind that SDGs function with one another in an interconnected way. For example, the achievement of SDG 4 is closely linked with the attainment of SDG 1 (no poverty), SDG 3 (good health and well-being), SDG 5 (gender equality), SDG 8 (decent work and economic growth), and SDG 10 (reduced inequalities) (Nikolova & Suleimenova, 2019).

8 Limitations and recommendations

Although this research provides valuable insights, it has certain limitations that need to be acknowledged. First, ILSAs, like PIRLS, have a narrow focus on specific areas of literacy and numeracy that may overlook other crucial aspects of quality education, including critical thinking, creativity, and socio-emotional skills. These skills are also essential components of SDG 4, and their exclusion may lead to an incomplete understanding of educational quality.

Second, there are certain limitations when measuring progress towards SDG 4, including underlying gender-based disparities in educational outcomes. It is recommended that more research be conducted on these disparities. Additionally, PIRLS data does not capture some SDG 4 indicators, such as completion rates. Therefore, it is suggested to incorporate data from alternative sources that track completion rates and other relevant indicators. These sources could include national educational statistics, reports from UNESCO, or other international assessments that include broader educational metrics. A multi-source approach can better evaluate all SDG 4 targets and enhance the overall understanding of educational progress.

Lastly, the data analysis approach has limitations. As with any secondary analysis, the available data are utilized without the advantage of adding other data that may be relevant to the analyses. It must also be noted that the use of linear regression methods only establishes relationships between predictor and outcome variables, not causality.

9 Conclusion

This research highlights the vital role of SDG 4 in achieving the remaining SDGs by demonstrating its interconnectedness with other aspects of the SDG agenda. Several sources, including Madalinska-Michalak (2023), OECD (2017), Priyadarshini (2019), UNESCO (2021), and the UN (2018) have supported this notion. This research emphasizes that reading comprehension and early childhood development are essential for literacy as an outcome of quality education. Additionally, empirical data sources play a significant role in establishing systemic relations between role players. The study further emphasizes that ILSAs, as the body of empirical evidence, not only support the targets set by the SDGs but also make these targets measurable and concrete. This research shows that SDG 4 and ILSAs like PIRLS play a crucial role in providing empirical evidence for quality education and are important for achieving other SDGs. The study also highlights the need for collective action to ensure everyone has access to safe learning opportunities, quality education, and improvement of literacy from an early age.

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