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Enhancing 21st Century Skills in Students with Special Needs Through STEM Learning

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Abstract

STEM learning has been recognized for its potential to improve critical, creative, collaborative, and communicative skills—key components of 21st-century competencies. For students with special needs, STEM-based approaches can offer tailored opportunities to develop these skills through active and interactive learning methods. This study aims to identify patterns of STEM learning implementation that contribute to the development of 21st-century skills in students with special needs. A descriptive qualitative approach was employed, involving data collection from Giwangan State Elementary School in Yogyakarta. Respondents included a teacher and a special assistant teacher for the 4th grade. Data collection techniques consisted of field observations, semi-structured interviews with 18-27 questions, and document analysis. The data were analyzed using qualitative content analysis, including reduction, presentation, and conclusion drawing, while validity was ensured through source triangulation. The findings reveal that STEM learning is conducted in three stages: introductory, main, and closing phases. This method engages students with special needs in problem-solving and group projects integrating science, technology, engineering, and mathematics. The observed activities enhanced students' motivation, interest in learning, and the development of critical thinking, collaboration, and communication skills. The study highlights the effectiveness of STEM learning in fostering 21st-century skills among students with special needs, offering an inclusive and interactive framework for educators to implement in similar contexts.

Keywords: inclusive education, STEM learning, student with special needs

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1. Introduction

21st-century learning emphasizes mastery of knowledge and skills in science and technology. Education must be inclusive and adaptive, providing equal opportunities for all students, including those with special needs (Ainscow et al., 2006). The keys to success are advanced technology, innovative teaching strategies, and supportive learning environments. The goal is to address individual needs, support diversity, and empower all students to face future challenges (Sjöström & Talanquer, 2014).

In a narrow understanding of inclusion (Göransson & Nilholm, 2014), students with special needs have physical, mental, intellectual, social, and emotional characteristics that are different from those of other children, and thus require special education services (Ulva, 2020; Ningrum, 2022). Every child with special needs is unique and requires a positive approach to develop their full potential (Lutfiyah et al., 2023; Normasari et al., 2021). They deserve an equal education with other students. The government supports this by creating inclusive schools that bring together students

with special needs and other students in the same class (Praptiningrum, 2010).

Students being categorized as having special needs can show differences in communication, physical mobility, attention, or cognition challenges (Arianti et al., 2022; Vai & Lorenza, 2019). Traditional education systems often lack the flexibility to adequately support these students. As for children without special needs, they can raise obstacles to successful education (Stinken-Rösner et al., 2020). For students to have 21st-century skills, education needs to be improved to teach the 4C skills: critical thinking, creativity, communication, and collaboration (Ridha et al., 2022; Triana et al., 2020).

Based on observations and interviews conducted at the elementary school in Giwangan, Yogyakarta, it has been noted that students with special needs tend to be less active and not interactive during lessons. This is largely because teachers still use "classic" learning methods such as teacher-centered lectures. This method does not follow project-based science learning, so students' interest and curiosity in science are low, contrary to the demands of the curriculum which requires student-centered learning. More innovative and integrated disciplines such as STEM (Science, Technology, Engineering, and Mathematics) are needed to overcome this problem.

STEM-integrated learning can be adapted to meet the needs of students with special needs (Isa, 2024). STEM learning for science subjects involves teachers in stimulating students' curiosity about science; training students to recognize tools that facilitate daily life (technology); guiding students to design systems to solve problems (engineering); and teaching students to make rational and logical arguments (math) (Arsy & Syamsulrizal, 2021; Wahyuni, 2021).

STEM-integrated learning alike has great potential to improve the quality of learning for students with special needs. With proper adaptation, STEM-integrated learning can help children with disabilities reach their full potential and become productive citizens (Adhelacahya et al., 2020). Another study also found that STEM-integrated learning can be a powerful tool to empower students with special needs. With proper adaptation, students can develop important 21st-century skills, such as problem-solving, creativity, and collaboration (Andrean et al., 2021).

Science learning in primary schools refers to the Merdeka Curriculum which allows schools to develop the curriculum according to student needs (Iskandar et al., 2023). The main objective is to develop students' understanding of the fundamentals of natural and social science concepts (Allutfia & Setyaningsih, 2023), as well as critical thinking, observation, experimentation, and problem-solving skills (Azzahra et al., 2023). STEM learning is effectively considered for social and science learning as it enables holistic and applied understanding. This model integrates science, technology, engineering, and mathematics, holistically.

STEM is integrated learning that focuses on solving problems in everyday life through experiments involving science, technology, engineering, and math (Khoiri, 2019). It improves critical thinking skills (Putri et al., 2020), helps develop creativity (Nurjanah, 2020; Sutiani & Pasaribu, 2023), encourages communication and collaboration (Mawaddah et al., 2022). These skills are very beneficial for the development of students with special needs. Therefore, researchers are interested in examining the potential of STEM-integrated learning toward the 21st-century skills of students with special needs and allow us to answer such as "How do we map their critical, creative, collaborative, and communicative skills as a result of STEM learning."

2. Research Method

This research uses a descriptive qualitative approach. The main reason for choosing descriptive qualitative research is that researchers conduct an in-depth exploration of programs, events, and activity processes in one or more people (Sugiyono, 2020). The

researchers deeply reveal the implementation of STEM learning for IPAS toward the 21st-century skills of students with special needs.

This research was conducted at Giwangan State Elementary School, Yogyakarta City, during the even semester of the 2023/2024 cohort. The research data was collected from class teachers and special assistant teachers of the 4th grade. The data collection technique in this research is observation and interview. The purpose is to find out the actual situation in the field (Moeleong, 2015; Prastowo, 2020). Additionally, the researchers also collect data from existing documents. Documents contain records of events that have occurred in the past and can support and strengthen the results of research (Cresswell, 2017).

The sample in this study was categorized into two groups: individuals and materials. We collected data from both samples. Data were gathered from both sample types. Specifically, interviews and observations focused on the activities of teachers and students during the science learning process in the classroom. This included examining how STEM-based learning was applied. Further exploration was conducted through observations of the science learning process, the application of STEM learning, and the classroom activities of teachers and students.

The researcher conducted semi-structured interviews about lesson plans, learning modules, students' worksheets, students learning outcomes, learning activities in the classroom, and students' behavior in learning. Therefore, the data analysis technique in this study is data reduction by grouping raw data related to the implementation of STEM learning for science subjects to improve the special needs students' skills through observation data. Further, the observed data were presented in the qualitative description to explain the phenomena more deeply.

Researchers analyzed and interpreted the data to obtain a deep understanding and conclusions (Sugiyono, 2016). Here, we administered qualitative content analysis through our developed instruments as a coding frame (Schreier, 2012). The technique used was data observed from the fieldwork was matched with the developed categories. Moreover, we also applied the triangulation method to ensure the validity of the research. Researchers compared the results of interviews from one informant with other informants and collaborated with some data related to the research, the aim was to obtain data validity. As noted, we apply anonymous respondents as shown in Table 1.

Table 1. Table of Research Respondents

No	Initial	Status	Gender
1	HL	4th Grade Teacher	Female
2	ID	Special Assistance Teacher	Female

3. Result and Discussion

3.1. The Pattern of STEM Learning for Science Subject Toward the 21st Century Skills of Students with Special Needs

STEM learning in the science subject for students with special needs at State Elementary Giwangan, Yogyakarta was implemented through three stages: introduction, core, and closing phases. Teachers often used media such as laptops, projectors, LCDs, and speakers, and followed the teaching modules that had been prepared. The learning process was implemented by utilizing relevant videos, images, and audio to support learning.

3.1.1. Introduction Phase

The preliminary activity in STEM-based science learning is that the teacher prepares students psychologically and physically to take part in the learning process. This is following the classroom teacher's statement *"I open the lesson by saying greetings, inviting students to pray together, checking student attendance, then making apperceptions and conveying learning objectives and benefits"* (HL, personal communication, 2024). This is supported by ID's statement that *"I prepare students' physical and psychological conditions at the beginning of the lesson by arranging the students' seating, with the children with special needs sitting in groups with other students"* (ID, personal communication, 2024).

Observations showed that the preliminary activities began with the teacher ensuring students' readiness through class organizing. Further, the students with special needs are placed together with regular students to encourage cooperation and participation. This seating placement is important, such as placing slow learners in ideal learning groups and deaf children in front so that they can easily ask the teacher if there is an explanation they do not understand. These activities may enhance their communication skills.

The next preliminary activity in STEM learning for science subjects is the teacher asking the trigger questions about previous knowledge linked to the present materials (apperception). Here, the class teacher expressed, *"I ask about the previous lesson material, then give questions that lead to the next learning material about their daily life"* (HL, personal communication, 2024). This is supported by the following ID's statement.

"I connect the material to daily life so that students can easily get an overview of the material to be learned. Thus, it can make it easier for students with and without disabilities to understand the previous and upcoming subject matter" (ID, personal communication, 2024).

Observations showed that the introductory activities continued with the teacher providing apperception, linking the new material with concepts that students already understood. Through this phase, students with special needs can try to think creatively.

The teacher starts with slow methods. It is aimed at attracting students with special needs to communicate. The apperception is often shifted to current materials, slowly. The teacher also asks questions about the previous material and the one to be learned, linking it to everyday life to make it easier for students to remember and understand the material.

3.1.2. Main Phase

The main phase for STEM-integrated learning for science subjects is that the teacher orients students to the problem. It is aimed at uncovering problem-solving and creative thinking skills. At this phase, there are three activities. In the first activity, students are asked to observe videos related to learning materials. This is included in the aspects of science and technology. As expressed by the class teacher, "*Students observe the video displayed on the LCD projector in class according to the material to be learned"* (HL, personal communication, 2024). This is supported by ID's statement that *"Deaf students, will easily understand by watching illustrated videos with written captions on the video. Slow learner students are specially assisted to be able to understand the contents of the video"* (ID, personal communication, 2024).

In the second activity, the teacher asks sparking questions that refer to the problems in the video that students have previously observed. This is included in the science aspect. As reflected by the class teacher, *"To arouse students' curiosity, I use sparking questions so that students are encouraged to find out the answers"* (HL, personal communication, 2024).

In the third activity, students analyzed the video shown by the teacher. The class teacher expressed that *"After students are given stimulating questions, students are asked to analyze videos related to the topic to get answers to the questions we give"* (HL, *personal communication,* 2024). Here, collaboration skills can appear from working together with students with and without special needs.

The next core activity in STEM learning for science subjects is how the teacher organizes students to learn. Therefore, the class emphasizes science and math aspects. This activity would potentially encourage students with special needs to discover new experiences about material movement. First, students are formed into groups and pay attention to the instructions given. The class teacher considers heterogeneous groups, including students with special needs. It follows the concept of inclusive education (Stinken-Rösner et al., 2020). The teacher said,

"During learning, students are formed into several groups" (HL, personal communication, 2024). This is supported by the following ID's statement *"Students with special needs join the heterogeny groups. In a group, there must be one student with special needs, which aims to enable them to interact and build self-confidence so that they are not inferior to other students"* (ID, personal communication, 2024).

In the second activity, students are given the worksheet. As revealed by the class teacher as follows *"Students are given worksheets whose contents are tasks that students must do, containing instructions, steps, and how to complete tasks related to the material"* (HL, personal communication, 2024). Observations showed that teachers provide worksheets to help students complete the tasks given. Students pay attention to the worksheets given by the teacher. The special assistant teacher assisted the students with special needs in understanding the tasks given in the worksheet.

Concerning the science experiment, students observe a picture of a moving spiral paper, displayed by the teacher. Students are asked to observe this picture, which encourages their curiosity about how the spiral paper can move on its own. The observation results prove that this picture attracts students' attention and raises many questions about the mechanism of the spiral paper movement. Here, students discuss the moving spiral paper image and seek information on the design of a product that can move. That is relevant to the teacher's statement, *"After students observe the picture displayed, students discuss how to design spiral paper so that it can move. This activity trains students' communication and cooperation, both from students with disabilities and students without disabilities"* (HL, personal communication, 2024).

Observations showed that students were actively discussing how to design the spiral paper so that it could move as previously observed. Deaf students were accompanied by a special assistant teacher to communicate information, while slow learners were accompanied by a special assistant teacher to provide detailed and repeat explanations until they were well understood. Those activities are proven to increase collaboration and communication skills effectively.

The next core activity in STEM learning for science subjects is that the teacher guides individual and group investigations, including STEM components that integrate technology, math, and engineering, embedded. There are four activities: students read the steps to make moving spiral paper, prepare tools and materials, design and make spiral paper in groups, and test the spiral paper they have made. The teacher said, *"Students are guided from the beginning to prepare tools and materials, understand the steps of designing, making, and testing the moving spiral paper they have made"* (HL, personal communication, 2024). This is supported by ID's statement that *"By guiding investigations effectively, teachers can help students develop a variety of important skills and knowledge"* (ID, personal communication, 2024).

Observations showed that students in the group began to practice the experiment by making a spiral pattern using a pencil on cardboard, cutting it following the pattern, punching holes in the ends with a needle, inserting and tying the thread, and hooking the ends of the thread on the skewer chopsticks. Students then lit the candle and positioned the paper about 5 cm above the flame (without touching the flame) and observed the spiral paper moving on its own.

Partnership for 21st-Century Learning defines the pattern of 21st-century skills as critical thinking to solve problems, communication, collaboration, and creativity (Battelle for Kids, 2019). STEM learning also has the potential to enhance communication skills, as conveyed by HL, *"Here, the teacher guided students in presenting their work both individually and in groups is very important to do"* (HL, personal communication, 2024). This is supported by ID's statement that *"We guide students in the presentation and provide feedback or appreciation to students about their work"* (ID, personal communication, 2024).

Observations proved that students in groups discussed the type and transformation of energy that made the spiral paper move in their experiment. They wrote down the results of the discussion on the worksheet provided. Group representatives then presented the results of their experiments, which were responded to by other groups. The teacher also gave feedback and observed the attitude and skills of each student in the group.

3.1.3. Closing Phase

The closing phase in STEM learning for science subjects is that the teacher allows students to ask about any material they may not have understood, provides feedback, and gives assignments as a follow-up to the learning. The class teacher noted, *"Before the learning activities are closed, students are given time to ask questions if there is still material they have not understood yet"* (HL, personal communication, 2024). This is supported by ID's statement that *"especially for children with special needs, the teacher approaches them one by one to check if they have any questions related to the material"* (ID, personal communication, 2024).

Observations proved that in the closing phases, the teacher provided opportunities for students to ask questions related to material that had not been understood. The special assistant teacher visited the children with special needs one by one to ensure whether there was material that the students had not understood.

Similar findings also show that the implementation of STEM learning significantly improves problem-solving and communication skills in students with special needs (Astutik, 2020). Students in the experimental group were able to design creative solutions to the given problem and convey their ideas more clearly compared to the control group (Hamidaturrohmah et al., 2023). STEM learning is considered a promising approach because it integrates various disciplines, encourages problem-solving, and develops critical thinking skills (Rahmawati & Basith, 2023). This indicates that the STEM approach can accommodate various learning styles and abilities of students with special needs.

3.2. The Impact of STEM-Integrated Science Subjects in Improving the Learning Outcomes of Students with Special Needs

Integration of STEM learning for science subjects has enhanced in improving the 21st century skills as learning outcomes of students with special needs at State Elementary School Giwangan. Further, the interview results show that a positive impact also appears from their participation in class. Research reports that learning outcomes for students with special needs are adaptive skills through their participation (Dell'Anna et al., 2022). It is proven that *"Slow learner students are very active when there are learning practices, they are very enthusiastic in experimental activities or projects in science learning"* (ID, personal communication, 2024). This is supported by the following statement.

"Students with special needs are happier and more interested when they participate in learning which is carried out by technology through images or short videos related to the material. This is also very helpful for students with deaf classification who feel less clear if only explained by the teacher in front of the class" (HL, personal communication, 2024).

In addition, the observed learning outcomes also can be depicted with their critical thinking skills, as expressed by the class teacher as follows *"For students with slow learner classification, it is very important to be trained to be able to think critically, by expressing their opinions, fostering curiosity to question information related to the material, and making students think critically to find answers"* (HL, personal communication, 2024).

Second, collaboration skills, as expressed by the class teacher as follows *"STEM-based for science subject makes students with special needs accustomed to collaborating with other students. Students can work together in small groups to complete tasks or projects related to the subject matter"* (HL, personal communication, 2024).

Third, communication skills, as expressed by the class teacher as follows *"STEM projects often require students to present their work in front of the class. This helps them to develop their ability to speak or communicate in public"* (HL, personal communication, 2024). This is supported by ID's statement that *"students with special needs often feel less confident to communicate with their friends. Therefore, with STEM, students are required to be able to hone their speaking skills both with group friends and during presentations in front of the class"* (ID, personal communication, 2024*).*

Similar findings also show that the application of STEM-based learning for students with special needs in elementary schools has great potential to improve students' skills and understanding (Sukmana, 2018). The results of the data analysis showed a significant increase in science process skills, problem-solving, and creativity of experimental group students who participated in STEM learning compared to the control group (Huang & Pei, 2024). Previous research shows the effectiveness of STEM learning in improving various student skills (Mayerhofer et al., 2024). The observed science process skills in the experimental group can be explained through experiment activities that require students to observe, measure, and analyze data (Jatmika et al., 2020). Meanwhile, the improvement in problem-solving skills and creativity can be attributed to STEM projects that encourage students to design, build, and evaluate solutions to given problems (Nuraeni et al., 2021).

4. Conclusion

The STEM learning for science subjects could, qualitatively, enhance the 21st-century skills of students with special needs at State Elementary School Giwangan. Those are categorized into three, communication, collaboration, and critical thinking to solve the problem through three learning stages: introductory, main, and closing phases.
According to STEM learning implementation, teachers have used existing digital media to support students with special needs. The learning process is implemented according to the teaching module that has been prepared previously. STEM learning for science subjects uses active and interactive learning, where students with special needs are directly involved in problem-solving and making science projects with other students in groups, by containing components of science, technology, engineering, and mathematics in one subject matter.

The application of STEM-integrated science subjects in improving the skills of students with special needs at the State Elementary School Giwangan has a positive impact on increasing the student participation and interest in learning of students with special needs, developing various skills of students with special needs such as critical thinking, collaboration, and communication. Yet, inclusion education should be implemented for science disciplines at the high level like chemistry with a properly designed learning environment.

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References

Adhelacahya, K., Said, A. A. N., & Habsari, R. A. (2020). Inovasi Pembelajaran Berbasis Science, Technology, Engineering and Mathematics (STEM) pada Anak Berkebutuhan Khusus di Era Revolusi Industri 4.0. *Jurnal Ilmiah Penalaran dan Penelitian Mahasiswa*, *4*(1), 147-164. Retrieved from https://jurnal.ukmpenelitianuny.id/index.php/jippm/article/view/182

Ainscow, M., Booth, T., & Dyson, A. (2006). *Improving Schools, Developing*

Inclusion (1st Edition). Routledge. https://doi.org/10.4324/9780203967157

Allutfia, F. T., & Setyaningsih, M. (2023). Analisis Kesiapan Guru dalam Menghadapi Kurikulum Merdeka Mata Pelajaran IPAS Kelas IV. *Academy of Education Journal*, *14*(2), 326–338. https://doi.org/10.47200/aoej.v14i2.1656

Andrean, H., Pradipta, R. F., & Purnamawati, F. (2021). The Importance of Technology Education for Children with Special Needs in Inclusive Schools. *Proceedings of the 7th International Conference on Education and Technology (ICET 2021),* 81–84. Retrieved from https://www.atlantis-press.com/proceedings/icet-21/125964548

Arianti, R., Sowiyah, S., Handoko, H., & Rini, R. (2022). Learning of Children with Special Needs in Inclusive Schools. *Journal of Social Research*, *2*(1), 142–147. https://doi.org/10.55324/josr.v2i1.474

Arsy, I., & Syamsulrizal, S. (2021). Pengaruh Pembelajaran STEAM (Science, Technology, Engineering, Arts, And Mathematics) terhadap Kreativitas Peserta Didik. *Biolearning Journal*, *8*(1), 24–26. https://doi.org/10.36232/jurnalbiolearning.v8i1.1019

Astutik, I. S. (2020). Pengembangan Media Pembelajaran Kincir Angin Berbasis STEM untuk Meningkatkan Keterampilan Mengomunikasikan Siswa Inklusi Kelas 4 Sekolah Dasar. *Jurnal Didaktika Pendidikan Dasar*, *4*(3), 723-740. https://doi.org/10.26811/didaktika.v4i3.132

Azzahra, I., Aan Nurhasanah, & Eli Hermawati. (2023). Implementasi Kurikulum Merdeka pada Pembelajaran IPAS di SDN 4 Purwawinangun. *Didaktik : Jurnal Ilmiah PGSD STKIP Subang*, *9*(2), 6230–6238. https://doi.org/10.36989/didaktik.v9i2.1270

Battelle for Kids. (2019). *Framework for 21st Century Learning Definitions*. Retrieved from https://www.battelleforkids.org/insights/p21-resources/

Cresswell, J. W. (2017). *Research Design: Qualitative, Quantitative and Mixed Method Approaches.* California: Sage Publication, Inc.

Dell'Anna, S., Pellegrini, M., Ianes, D., & Vivanet, G. (2022). Learning, Social, and Psychological Outcomes of Students with Moderate, Severe, and Complex Disabilities in Inclusive Education: A Systematic Review. *International Journal of Disability, Development and Education*, *69*(6), 2025–2041. https://doi.org/10.1080/1034912X.2020.1843143

Göransson, K., & Nilholm, C. (2014). Conceptual Diversities and Empirical Shortcomings- A Critical Analysis of Reasearch on Inclusive Education. *European Journal of Special Needs Education,* *29*(3), 265-280. https://doi.org/10.1080/08856257.2014.933545

Hamidaturrohmah, Muhaimin, M., Sholikhah, A., & Nailufar, D. A. (2023). Pengembangan Buku Suplemen Intervensi Life Skill Berbasis STEAM bagi Anak Berkebutuhan Khusus di Sekolah Dasar Inklusi. *Indonesian Journal of Humanities and Social Sciences*, *4*(3), 609-622. Retrieved from https://ejournal.uit-lirboyo.ac.id/index.php/IJHSS/article/view/4338

Huang, L., & Pei, X. (2024). Exploring the Impact of Web-based Inquiry on Elementary School Students' Science Identity Development in a STEM Learning Unit. *Humanities and Social Sciences Communications*, *11*(1), 885.

https://doi.org/10.1057/s41599-024-03299-5

Isa, S. S. P. M. (2024). The Project-Based Learning (STEM Model) in Fundamental Physics Learning. *International Journal of Modern Education (IJMOE)*, *6*(21), Article 21. https://gaexcellence.com/index.php/ijmoe/article/view/621

Iskandar, S., Rosmana, P. S., Farhatunnisa, G.m Mayanti, I., Apriliya, M., Gustavisiana, T. S. (2023). Implementasi Kurikulum Merdeka di Sekolah Dasar. *Innovative: Journal of Social Science Research, 3*(2), 2322-2336. Retrieved from https://j-innovative.org/index.php/Innovative/article/view/572

Jatmika, S., Lestari, S., Rahmatullah, R., Pujianto, P., & Dwandaru, W. S. B. (2020). Integrasi Project Based Learning dalam Science Technology Engineering and Mathematics untuk Meningkatkan Keterampilan Proses Sains dalam Pembelajaran Fisika. *Jurnal Pendidikan Fisika dan Keilmuan (JPFK)*, *6*(2), Article 2. https://doi.org/10.25273/jpfk.v6i2.8688

Khoiri, A. (2019). Meta Analysis Study: Effect of STEM (Science Technology Engineering and Mathematics) towards Achievement. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *9*(1), 71–82. https://doi.org/10.30998/formatif.v9i1.2937

Lutfiyah, L., Murtinasari, F., & Sulisawati, D. N. (2023). The Level of Dyscalculia in Children with Special Needs in Understanding Mathematical Concepts: Learning Difficulties Experienced. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, *9*(2), 696–705. https://doi.org/10.33394/jk.v9i2.7848

Mawaddah, R., Triwoelandari, R., Irfani, F., Ibn, U., & Bogor, K. (2022). Kelayakan LKS Pembelajaran IPA Berbasis STEM untuk Meningkatkan Keterampilan Kolaborasi Siswa SD/MI. *Cakrawala Pendas*, *8*(1), 1–14. Retrieved from https://ejournal.unma.ac.id/index.php/cp/article/view/1911

Mayerhofer, M., Lüftenegger, M., & Eichmair, M. (2024). The Development of Mathematics Expectancy-value Profiles during the Secondary–tertiary Transition into STEM Fields. *International Journal of STEM Education*, *11*(1), 31. https://doi.org/10.1186/s40594-024-00491-6

Moeleong, L. J. (2015). *Metodologi Penelitian Kualitatif*. Bandung: PT Remaja Rosdakarya.

Ningrum, N. A. (2022). Strategi Pembelajaran pada Anak Berkebutuhan Khusus dalam Pendidikan Inklusi. *Indonesian Journal of Humanities and Social Sciences*, *3*(2), Article 2. retrieved from https://ejournal.uit-lirboyo.ac.id/index.php/IJHSS/article/view/3099

Normasari, E., Fitrianawati, M., & Rofiah, N. H. (2021). Akseptabilitas Orang Tua terhadap Anak Berkebutuhan Khusus di Kota Yogyakarta (Studi Kasus pada Lembaga Federasi Komunikasi Keluarga Penyandang Disabilitas). *Wasis : Jurnal Ilmiah Pendidikan*, *2*(2), 133–139. https://doi.org/10.24176/wasis.v2i2.6927

Nuraeni, F., Malagola, Y., Pratomo, S., & Putri, H. E. (2021). Trends of Science Technology Engineering Mathematics (STEM)-based Learning at Elementary School in Indonesia. *Premiere Educandum : Jurnal Pendidikan Dasar Dan Pembelajaran*, *11*(1), 87. https://doi.org/10.25273/pe.v11i1.8805

Nurjanah, N. E. (2020). Pembelajaran STEM Berbasis Loose Parts Untuk Meningkatkan Kreativitas Anak Usia Dini. *Jurnal Audi: Jurnal Ilmiah Kajian Ilmu*

Anak dan Media Informasi PAUD, *V*(1), 19–31. Retrieved from https://ejurnal.unisri.ac.id/index.php/jpaud/article/view/3672

Praptiningrum, N. (2010). Fenomena Penyelenggaraan Pendidikan Inklusif bagi Anak Berkebutuhan Khusus. *JPK (Jurnal Pendidikan Khusus)*, *7*(2), 32–39. retrieved from https://journal.uny.ac.id/index.php/jpk/article/view/774

Prastowo, A. (2020). *Metode Penelitian Kualitatif dalam Perspektif Rancangan Penelitian*. Yogyakarta: Ar-Ruzz Media.

Putri, C. D., Pursitasari, I. D., & Rubini, B. (2020). Problem Based Learning Terintegrasi STEM di Era Pandemi Covid-19 untuk Meningkatkan Keterampilan Berpikir Kritis Siswa. *Jurnal IPA & Pembelajaran IPA*, *4*(2), 193–204. https://doi.org/10.24815/jipi.v4i2.17859

Rahmawati, I., & Basith, A. (2023). Life Skills Education Based on Local Excellence: Studi of State Special Schools Students in East Kalimantan. *Qalamuna: Jurnal Pendidikan, Sosial, dan Agama*, *15*(2), 729–744. https://doi.org/10.37680/qalamuna.v15i2.2497

Ridha, M. R., Zuhdi, M., & Ayub, S. (2022). Pengembangan Perangkat Pembelajaran PjBL berbasis STEM dalam Meningkatkan Kreativitas Fisika Peserta Didik. *Jurnal Ilmiah Profesi Pendidikan*, *7*(1), 223–228. https://doi.org/10.29303/jipp.v7i1.447

Schreier, M. (2012). *Qualitative Content Analysis in Practice*. London: SAGE Publication Ltd.

Sugiyono. (2016). *Metode Penelitian Kuantitatif Kualitatif dan R&D*. Bandung: Alfabeta.

Sugiyono. (2020). *Metode Penelitian Kuantitatif, Kualitatif dan Kombinasi (Mixed Methods)* (Cetakan ke-10). Bandung: Alfabeta.

Sukmana, R. W. (2018). Implementasi Pendekatan STEM (Science, Technology, Engineering and Mathematics) untuk Meningkatkan Keterampilan Berpikir Kritis Siswa di Sekolah Dasar. *Primaria Educationem Journal (PEJ)*, *1*(2), 113-119. Retrieved from http://journal.unla.ac.id/index.php/pej/article/view/1081

Sutiani, A., & Pasaribu, C. J. T. (2023). Fostering Scientific Literacy through Integrated STEM Teaching Materials on Basic Laws of Chemistry. *Jurnal Tadris Kimiya*, *8*(1), 95–103. https://doi.org/10.15575/jtk.v8i1.25833

Sjöström, J., & Talanquer, V. (2014). Humanizing Chemistry Education: From Simple Contextualization to Multifaceted Problematization. *Journal of Chemical Education*, *91*(8), 1125–1131. https://doi.org/10.1021/ed5000718

Stinken-Rösner, L., Rott, L., Hundertmark, S., Baumann, T., Menthe, J., Hoffmann, T., Nehring, A., & Abels, S. (2020). Thinking Inclusive Science Education from two Perspectives: Inclusive Pedagogy and Science Education. *Research in Subject-matter Teaching and Learning*, *3*, 30-45. https://doi.org/10.23770/rt1831

Triana, D., Anggraito, Y. U., & Ridlo, S. (2020). Effectiveness of Environmental Change Learning Tools Based on STEM-PjBL Towards 4C Skills of Students. *Journal of Innovative Science Education*, *9*(2), 181-187. Retrieved from https://journal.unnes.ac.id/sju/jise/article/view/34048

Ulva, M., & Amalia, R. (2020). Proses Pembelajaran Matematika pada Anak Berkebutuhan Khusus (Autisme) di Sekolah Inklusif. *Journal on Teaching Education*, *1*(2), 9–19. https://doi.org/10.31004/jote.v1i2.512

Vai, A., & Lorenza, J. (2019). Implementasi Pembelajaran Penjas Adaptif pada Anak-Anak Kebutuhan Khusus di Sekolah Dasar Inklusif. *Altius: Jurnal Ilmu Olahraga dan Kesehatan*, *8*(1), 9–14. https://doi.org/10.36706/altius.v8i1.8243

Wahyuni, N. P. (2021). Penerapan Pembelajaran Berbasis STEM untuk Meningkatkan Hasil Belajar IPA. *Journal of Education Action Research*, *5*(1), 109-117. https://doi.org/10.23887/jear.v5i1.31554