Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar JPPGuseda

Volume 8 Issue 3 Year 2025 Pages 136-144
ISSN 2623-0941 | e–ISSN 2623-0232
https://jppguseda-fkip.unpak.ac.id
DOI: 10.55215/jppguseda.v8i3.14

Development of STEM-Based Science Process Skills Assessment Instruments in Elementary Schools Science Learning

Marzella Putri Octaviani, Astri Sutisnawati, Din Azwar Uswatun
marzella038@ummi.ac.id, astrisutisnawati@ummi.ac.id, dinazwar@ummi.ac.id

Faculty of Teacher Training and Education, Universitas Muhammadiyah Sukabumi, Sukabumi, Indonesia

*Correspondence to: *Marzella Putri Octaviani*
Universitas Muhammadiyah Sukabumi
Jl. R. Syamsudin, SH. No. 50. Kota Sukabumi, Indonesia
email: marzella038@ummi.ac.id

Abstract: The aims of this study is to describe the feasibility and practicality of the STEM EDP-based science process skills assessment instrument in elementary science learning. The research method used is Research and Development (R&D) with the ADDIE model. Data collection techniques, i.e.: interview, work show and questionnaire. Research instruments consisting of interview sheets, assessment rubrics, expert validation questionnaire sheets, practitioners and student responses. The results of the research obtained are: 1) The analysis stage consists of a needs analysis. 2) The design stage, namely designing a STEM-EDP-based science process skill assessment instrument in elementary science learning is adjusted to the material in the science book chapter 4 changing the form of energy, Topic A: energy transformation around us. 3) Development stage, namely developing products and conducting validation tests of experts and practitioners. All data was obtained using a questionnaire submitted to the validator. The results of the expert validation test received an average percentage of 84.72% in the "Feasible" category. The results of the practitioner validation test received an average percentage of 93.06% with the category of "Very Practical". 4) The implementation stage is to apply the developed product to a test group involving 18 students. The results of product trials in each aspect of the indicator get the lowest percentage of 75% and the highest 100%. Then, the students' responses received an average percentage of 83,46% with the category "Positive".

Keywords: assesment instrument; edp; elementary science learning; science process skills; stem

Article info: Submitted September 25, 2025 | Revised November 18, 2025 | Accepted November 27, 2025

Recommended citation: Octaviani, M. P., Sutisnawati, A., & Uswatun, D. A. (2025). Development of STEM-based science process skills assessment instruments in elementary schools science learning. *Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar (JPPGuseda)*, 8(3), 136–144. https://doi.org/10.55215/jppguseda.v8i3.14

Introduction

Learning is a process of activities aimed at achieving certain competencies or behaviors that students can possess after completing learning activities. To determine whether learning objectives have been achieved, assessment of student learning outcomes is necessary (Mustafa & Dwiyogo, 2020; Bada & Olusegun, 2015). Learning assessment is the process of assigning grades based on measurement results that have been adjusted to indicators developed by the teacher. Assessment of learning outcomes is carried out by teachers using instruments that have been designed with appropriate benchmarks. Assessment instruments function as a tool for collecting data on student achievement (Mustafa & Masgumelar, 2022). Assessment plays a crucial role in improving the quality of education in Indonesia, as it is a crucial part of the learning process. Based on Bloom's Taxonomy theory, there are several aspects of assessment, namely cognitive (knowledge), affective (attitudes), and psychomotor (skills) (Levy-Feldman, 2025; Ana et al., 2023).

Teachers can apply several assessment techniques, including tests and non-test techniques. Non- test techniques, such as observation or performance assessments, can be used, including statements and assessment rubrics (Mahendra et al., 2024; Viswesvaran & Ones, 2018). Science process skills, in particular, require an appropriate assessment system. Science process skills fall within the psychomotor domain. Science process skills are scientific activities that help students broaden their horizons and develop their intellectual, social, and physical abilities through the use of their basic skills. Putri (2019) explains that science process skills are the scientific ability to obtain information and think deeply in establishing concepts, facts, and principles. Assessing science process skills is crucial because it can measure students' development in

activities such as practical work. Assessment also provides an opportunity for students to reflect on their learning progress. Through feedback and assessment results, students can monitor progress, identify areas for improvement, and develop their skills (Fajrina et al., 2021).

Based on interviews with teachers, it was found that the science process skills (SPS) assessment instrument for practical work was rarely used. Teachers' assessments were limited to observing the final results and recording the scores directly on the summary sheet. The assessment sheets used by teachers were not equipped with an assessment rubric. Furthermore, teachers had not fully implemented the SPS indicators in the assessment instruments. The SPS indicators used were still general, such as observation, planning experiments, conducting experiments, using tools and materials, and communication. Students' science process skills were considered quite good because teachers only assessed them without observing the process. Therefore, the SPS instrument in science learning is very necessary because it plays a crucial role in student learning outcomes.

Science process skills provide hands-on experiences that can motivate someone to pursue their curiosity. Therefore, science process skills play a crucial role in learning, especially for students, as they not only engage them directly but also motivate them to explore and understand more through real-life experiences (Yuliati & Susianna, 2023). To measure students' science process skills, the STEM approach can be used. The STEM (Science, Technology, Engineering, and Mathematics) approach is an interdisciplinary approach that combines four main fields: science, technology, engineering, and mathematics, in real-world contexts. This aligns with Bybee's assertion that the STEM approach can help students apply the core of each STEM discipline in various life situations and can develop students' thinking across various aspects of knowledge (Mu'minah & Suryaningsih, 2020; Nurramadhani et al., 2024). One of STEM's strengths is its ability to address concerns about the appropriate approach to science learning. STEM is the right approach to shaping individuals who are ready to face the future (Santoso & Arif, 2021; Nurramadhani et al., 2020).

STEM is often combined with other learning models, such as STEM through the Engineering Design Process (EDP) (Deke et al., 2022). EDP is a systematic model for solving real-world problems and solutions developed through a series of structured steps that strengthen students' critical thinking and skills and teach them to apply knowledge comprehensively (Yu et al., 2020). EDP aims to create assessment instruments that emphasize problem-solving, encouraging students to innovate in designing solutions, gathering necessary information, and facing real-world challenges (Syukri et al., 2023). This aligns with Nuraeni & Zahra (2021) assertion that implementing EDP enhances students' deeper understanding of science concepts. This is due to the activities students undertake, which provide experiences connecting specific science concepts and applying them to solve problems in real-world contexts.

Based on previous research, the application of the science, technology, engineering, and mathematics (STEM) approach in the classroom can improve science process skills (Akbariah et al., 2023; Sarı et al., 2020). This allows students to be creative, innovative, and active in learning, including in solving problems in groups, so that students can think critically, creatively, and understand science subjects more deeply. Research by (Thovawira et al., 2021) shows that the implementation of the STEM approach has a positive impact on students, such as improving creative thinking skills and the abilities needed to face the era of the industrial revolution 4.0. In addition, research on the application of the Engineering Design Process (EDP) model by Berland shows that EDP can help students in solving problems and providing solutions, which are the result of students' own thinking abilities (Ulum et al., 2021). Research by Mifa also states that the implementation of EDP can develop students' abilities in identifying problems, determining solutions, designing prototypes, and creating models of problem-solving tools with good categories (Ulum et al., 2021).

STEM-EDP-based science process skills assessment instruments in science learning in elementary schools are still rarely developed, because most previous studies focused on the implementation of STEM or EDP at the junior high and senior high school levels without producing standardized assessment instruments to measure science process skills comprehensively through practical activities. Therefore, this study aims to develop a STEM-EDP-based science process skills assessment instrument specifically designed for science learning in elementary schools. The novelty of this study lies in the development of a standardized assessment instrument specifically designed to measure science process skills comprehensively in the context of practical activities. This study provides academic and practical contributions in the form of a valid assessment instrument that teachers can use to evaluate students' science process skills more accurately, thereby supporting the improvement of the quality of science learning and student learning outcomes.

Methods

This study employed a research and development (R&D) method, better known as research and development (R&D), which aims to produce a valid and practical product (Sugiyono, 2016). The R&D method

was used because the research encompasses not only user needs but also the product development process, which requires data collection and analysis, specifically the expert validation process. The research design employed the ADDIE model, as it is systematic and aligns with the theoretical foundations of instructional design (Rendra, 2018). This model was chosen for several reasons, including its systematic and simple presentation at each stage, making it easy for researchers to understand. The ADDIE development model consists of five stages: analysis, design, development, implementation, and evaluation.

This research was conducted from October to December at a public elementary school in Sukabumi City. The population used as research subjects were fourth-grade students in the 2024/2025 academic year. The sampling technique used was purposive sampling, a technique for selecting samples or data sources based on specific considerations. The sample was selected based on school recommendations. The data collection techniques used in this study were: 1) Interviews, 2) Performance Tests, and 3) Questionnaires. The research instruments used were: 1) Interview forms, 2) Assessment Rubrics, and 3) Validation questionnaires for experts, practitioners, and student responses. Data analysis techniques in this study included qualitative and quantitative data. Data were obtained from expert and practitioner validation results, as well as from product trials and student responses. The researchers used a Likert scale in data analysis. The Likert scale consisted of four rating categories: Very Good (score 4), Good (score 3), Quite Good (score 2), and Not Good (score 1).

Data analysis was carried out through several stages involving expert validation, practitioner validation, product trials, and student response assessments. Expert and practitioner validators assessed the developed product using predetermined rating criteria, and their scores were subsequently converted into percentage values. The resulting percentages were then interpreted into qualitative categories describing the product's feasibility and practicality, ranging from very worthy or very practical to not worthy or not practical. This approach enabled the researchers to obtain a clear evaluation of the product's quality from both theoretical and practical perspectives.

Furthermore, data from product trials and student responses were analyzed using percentage-based interpretations to determine the level of practicality and acceptance of the developed media. Student responses were measured using a Likert scale consisting of four levels, which were converted into quantitative scores and then transformed into percentage values. These percentages were subsequently interpreted into qualitative response categories, such as very positive (85% - 100%), positive (75% - 84%), quite positive (55% - 74%), or not positive (0%-54%). Through this multistage analysis process, the researchers obtained comprehensive insights into the feasibility, practicality, and acceptance of the developed learning media.

Result and Discussion

The research and development method used follows the steps of the ADDIE model. This research was conducted up to the evaluation stage. The following are the development results, along with validation and trial data:

Analysis

The initial stage of this research was the analysis phase. The research was conducted at a public elementary school in Sukabumi City on October 26th. Interviews with teachers revealed that the science process skills (SPS) assessment instrument for practical work was rarely used. Teachers' assessments were limited to observing the final results and directly recording the scores on a summary sheet. The assessment instrument used by teachers was also not equipped with an assessment rubric. Furthermore, teachers had not implemented all indicators of science process skills in the assessment instrument. The assessment instrument used was still general. Students' science process skills were considered quite good because teachers only assessed them without observing the process. This demonstrates the importance of assessment instruments that can be used to measure student skills. Without appropriate assessment instruments, it will be difficult to assess science process skills. This can lead to students' competency in practical work not being achieved (Wijaya et al., 2022). This situation suggests the need for innovation in SPS assessment instruments in science learning. This is because science process skills play a crucial role in student learning outcomes.

This innovation uses the STEM-EDP approach. The STEM (Science, Technology, Engineering, and Mathematics) approach combines four main fields: science, technology, engineering, and mathematics. According to Bybee, STEM can help students apply the core of each STEM discipline in various life situations (Mu'minah & Aripin, 2019). According to Deke (2022), STEM is often combined with the Engineering Design Process (EDP) learning model. EDP aims to create instruments that emphasize problem solving, encourage students to innovate in designing design solutions, gather needed information, and face real-world challenges (Syukri et al., 2023). Therefore, this study uses an innovative approach, namely STEM-EDP, which is expected to be an effective alternative.

Design

Science process skills are crucial for students to master because, compared to other skills, they can demonstrate the development of students' abilities in carrying out activities aimed at discovering a concept. This allows students to remember concepts more easily than simply memorizing them. Therefore, an appropriate assessment instrument design is needed to help teachers assess students' skills (Fadillah, 2017). The assessment instrument design is expected to be used in all elementary schools to assess science process skills. Therefore, the assessment instrument must also be clear and easy for teachers to use. In the design stage, researchers designed an assessment instrument based on the analysis results obtained. In this study, the product developed was a STEM- EDP-based science process skills assessment instrument in elementary school science learning. The assessment instrument, in the form of performance, was used to assess students' activities during practice (Mandolang et al., 2022). Furthermore, it was adapted to the curriculum and the material to be studied. The material used in this study was Chapter 4 Changing Forms of Energy, Topic A: Energy Transformations Around Us, contained in the fourth-grade science textbook. This was also adapted to the indicators of science process skills.

The assessment instrument format is divided into three stages: introduction, content, and closing. The introduction contains the product identity and instructions for using the assessment instrument. The content stage contains student worksheets (LKPD) developed using the STEM approach. STEM-based LKPD can improve critical thinking skills and foster students' creative thinking skills (Mahjatia et al., 2021). Furthermore, the content stage also includes an assessment rubric used as a reference in observing and assessing student skills. The use of a rubric is expected to reduce assessor subjectivity in the assessment process (Ratnawulan & Rusdiana, 2014). The closing stage contains recapitulation data and scoring guidelines to indicate the extent to which students have achieved the set objectives. Scoring also helps process results numerically, objectively, and fairly (Hasni et al., 2024). Furthermore, the developed instrument is also equipped with a cover, foreword, and table of contents. When designing the assessment instrument, the researcher made revisions based on the guidance of the supervising lecturer to improve the quality of the product to be developed.

Development

The development stage involves transforming the assessment instrument into a physical form for use. Key considerations include the instrument's appearance, language, and suitability to the STEM EDP, learning objectives, and process skill indicators. The development of a STEM EDP-Based Science Process Skills Assessment Instrument in Elementary School Science Learning for Grade 4 Energy Transformation was created using the Canva application.

The next stage is product validation. The validation results are accompanied by comments and suggestions from the validator, which serve as a reference for improvements before the product is used. According to (Dewi et al., 2020), a quality assessment instrument must have at least a high level of validity. The higher the validity, the more accurate and precise the data obtained in the research (Lahantaya, 2020). Therefore, a validity test is necessary to ensure that the instrument's content has good validity. If a measuring instrument can accurately measure what it is intended to measure, it is considered valid (Juliani & Erita, 2023). The results of the validation test questionnaire were carried out by two expert validators by filling out the assessment questionnaire.

Figure 1 presents the results of the expert and practitioner validation processes conducted for the STEM EDP–based science process skills assessment instrument. Expert validation was carried out by two validators from December 11th to 13th. The instrument consisted of three assessment aspects containing nine items. After the validation was completed, the researcher calculated the average score for all aspects using a Likert scale. The overall mean score from the two validators was 84.72%, indicating that the instrument was feasible for use with minor revisions. The first validator recommended aligning the instrument more closely with the teaching module implemented in schools, while the second validator suggested improving the clarity and structure of the language used in the instrument.

In addition to expert validation, the instrument was also evaluated by two practitioners (classroom teachers) at the research site on December 16th. Using the same assessment aspects and scoring procedure, the overall validation mean obtained from the practitioners was 93.06%, categorized as highly practical. These results indicate that the STEM EDP–based science process skills assessment instrument is practical and ready for implementation without further revision (**Figure 1**).

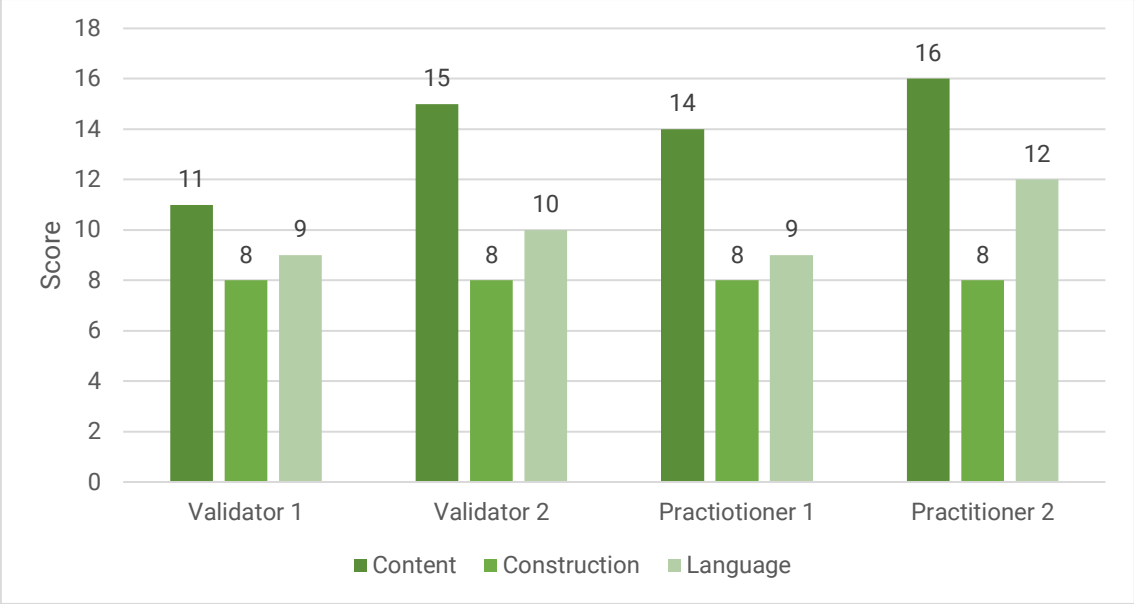

Figure 1. Validator and Practitioner Validation Results Diagram

Implementation

The implementation stage was carried out by applying the developed product to the test group. This trial involved 18 students. The activities carried out at this implementation stage involved the researcher teaching using a teaching module that had been created by applying the EDP Syntax to learning activities. In addition, the researcher also used an assessment instrument that included an assessment rubric using KPS indicators and STEM-based student worksheets. According to Fadilah et al. (2024) research, the application of the STEM approach with the EDP model can have a positive impact, namely being able to improve students' science process skills learning outcomes because it involves activities that provide direct learning experiences (**Figure 2**). Process skills are basic scientific abilities that must be possessed and mastered by students, especially to support education in the era of rapidly developing globalization (Nurhasanah et al., 2019). The trial of the STEM EDP-based science process skills assessment instrument was used when students were experimenting with making a simple water wheel.

Figure 2. Students test a simple water wheel

Figure 3 shows the results of the trial of the science process skills assessment instrument on students on December 16. The researcher conducted a trial while the students were performing an experiment to create a simple waterwheel. The assessment instrument for process skills used has 11 indicators, namely: 1) Observation, 2) Asking questions, 3) Hypothesis, 4) Planning the experiment, 5) Using tools and materials, 6) Conduct an experiment, 7) Clarification, 8) Prediction 9) Applying Concepts, 10) Interpretation, and 11) Communication. After conducting the pilot test, researchers calculated the average score for each indicator. The diagram shows that the observation, experimentation, classification, and communication indicators achieved 100% scores. Meanwhile, the lowest average score was the prediction indicator, which achieved 75%. Therefore, the implementation of the assessment instrument yielded positive results across all aspects of the indicator.

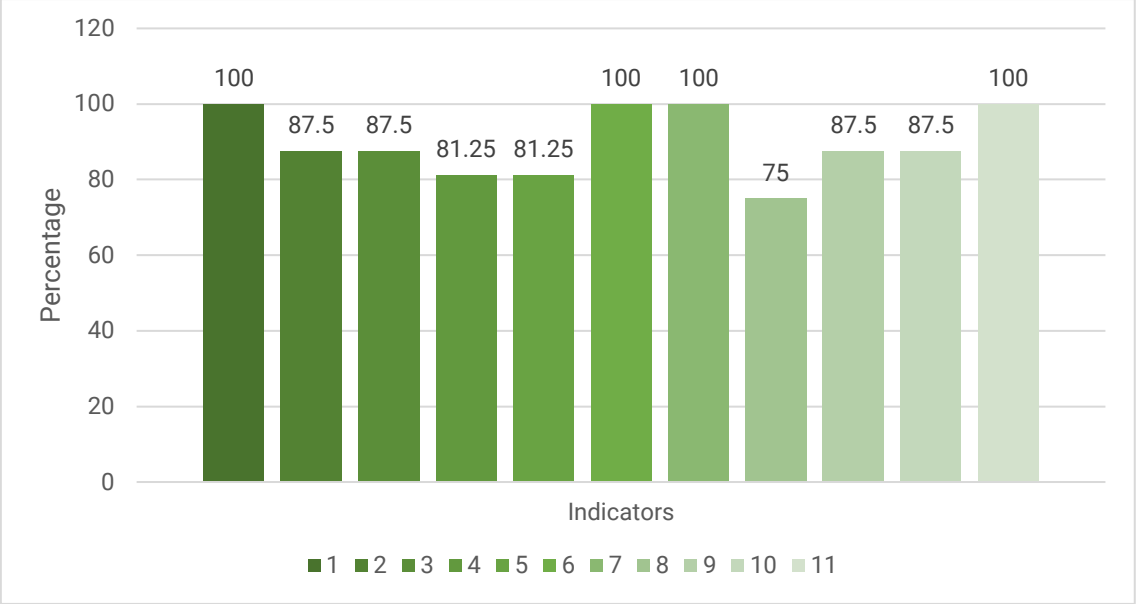

Figure 3. Product Trial Analysis Results Diagram

Figure 4 shows the results of student responses. The researcher provided a Google Form link to students to determine the practicality of the assessment instrument through their responses. The Google Form consisted of three aspects containing 15 questions. After receiving student responses, the researcher calculated the average for each student. The overall average obtained from 18 students was 83.46%, categorized as positive.

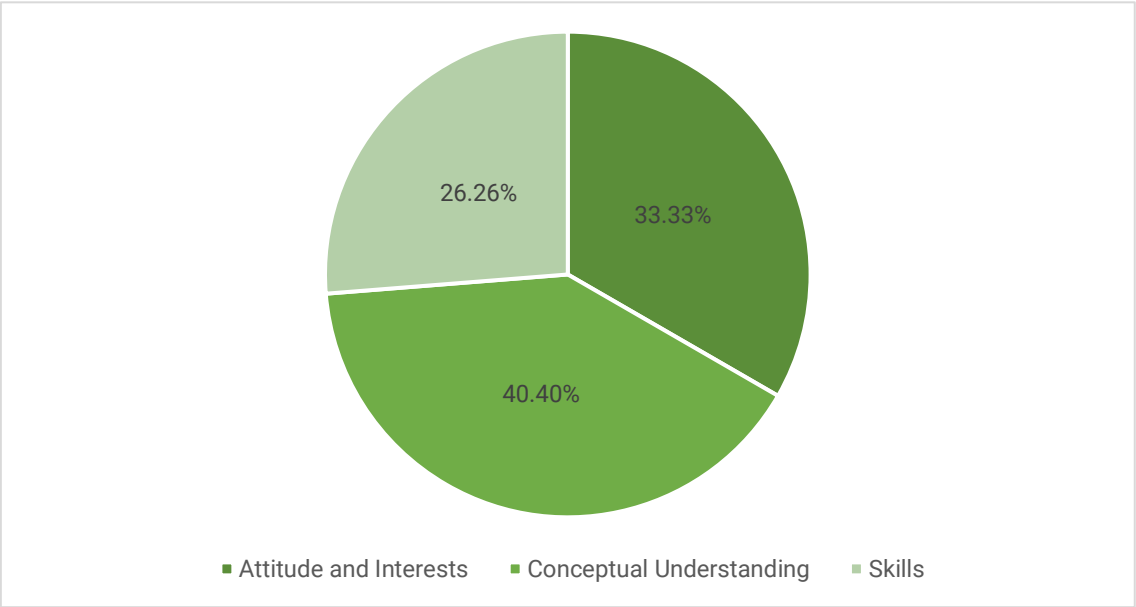

Figure 4. Student Response Results Diagram

Evaluation

The researchers did not make any revisions after the trial because the final expert validation results were categorized as "adequate." Furthermore, practicality, as measured by practitioner validation, was categorized as "very practical," and student responses were also categorized as "positive." These results indicate that the developed STEM-based science process skills assessment instrument (EDP) for elementary school science learning is feasible and practical for use.

Conclusion

Based on the research results and discussion, the following conclusions can be drawn: 1) The development of a STEM-based science process skills assessment instrument (EDP) in elementary science learning was validated by experts and practitioners. 2) The feasibility of the STEM-based science process skills

assessment instrument (EDP) in elementary science learning was measured by expert validation, with a categorized as feasible. 3) Practicality, measured by practitioner validation, with categorized as very practical. 4) Practicality was also assessed by student responses to the STEM-based science process skills assessment instrument (EDP) in elementary science learning, with categorized as positive. 5) The application of the STEM-based science process skills assessment instrument (EDP) during the practical work of making a simple water wheel achieved very practical. Thus, the STEM EDP-based science process skills assessment instrument in elementary school science learning is feasible and practical to be used as an assessment in learning, d) This research is expected to make it easier for teachers to measure students' science process skills in science learning and students' learning outcomes can be improved because STEM EDP-based science learning emphasizes direct experience.

References

Afifah, A. (2021). Peningkatan keterampilan proses sains siswa pada mata pelajaran IPA konsep tekanan zat cair melalui pendekatan STEM (science technology engineering mathematic) di kelas VIII SMPN 4 Kota Bogor. *Jurnal Pendidikan dan Pengajaran Guru Sekolah Dasar (JPPGuseda), 4*(1), 75–79.

Akbariah, N., Artika, W., Pada, A. U. T., Safrida, S., & Abdullah, A. (2023). A stem-based learning process analysis of students'science process skills. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 943-951.

Ana, J., Masriani, M., Sartika, R., Erlina, E., & Lestari, I. (2023). Pengembangan instrumen penilaian psikomotorik pada praktikum pemisahan kimia. *Jurnal Education and Development, 11*(2), 273–279.

Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education*, *5*(6), 66-70.

Deke, O., Jewaru, A., & Kaleka, Y. (2022). Engineering design process pada STEM melalui authentic PBL dan asesmen formatif: Meninjau desain argumentasi ilmiah siswa terkait termodinamika. *Borneo Journal of Science and Mathematics Education, 2*(3), 101–124.

Dewi, N., Rahmi, Y., Alberida, H., & Darussyamsu, R. (2020). Validitas dan reliabilitas instrumen penilaian kemampuan berpikir tingkat tinggi tentang materi hereditas untuk peserta didik SMA/MA. *Jurnal Eksakta Pendidikan, 4*(2), 138–146.

Fadilah, H. N., Milzandi, M. P., & Audrey, M. A. (2024). Worksheet-STEAM sebagai upaya melatih keterampilan proses sains siswa SMP. *Prosiding Seminar Nasional IPA Universitas Negeri Semarang*, 678–692.

Fadillah, E. N. (2017). Pengembangan instrumen penilaian untuk mengukur keterampilan proses sains siswa SMA. *Didaktika Biologi: Jurnal Penelitian Pendidikan Biologi*, 1(2), 123–134.

Fajrina, S., Nulhakim, L., & Taufik, A. N. (2021). Pengembangan instrumen performance assessment praktikum untuk mengukur keterampilan proses sains (KPS) siswa SMP kelas VIII pada tema *Makananku Kesehatanku*. *PENDIPA Journal of Science Education*, 6(1), 105–112.

Hasni, D. M., Mendrofa, I. N., Khairunnisa, R., Islami, N., Panggabean, S. H. S., Fitria, A., & Branco, M. V. (2024). Penilaian dan penskoran dalam evaluasi pembelajaran PAI. *Jurnal Pendidikan Tambusai*, 8(3), 45981–45992.

Juliani, R. P., & Erita, S. (2023). Analisis validitas dan reliabilitas instrumen penilaian kemampuan berpikir kritis dalam konteks sekolah menengah. *JEID: Journal of Educational Integration and Development, 3*(3), 169–179.

Lahantaya, O. (2020). *Validitas dan reliabilitas butir soal eksponen dan logaritma dalam buku siswa matematika peminatan berdasarkan Kurikulum 2013 di SMA Negeri 2 Banda Aceh* (Undergraduate thesis, Universitas Bina Bangsa Getsempena).

Levy-Feldman, I. (2025). The role of assessment in improving education and promoting educational equity. *Education Sciences*, *15*(2), 224.

Mahendra, K. Z., Diah, N. R., Rizqiah, Utami, V. L., & Marhadi, H. (2024). Analisis penilaian teknik tes dan non tes pada kelas IV di SD Negeri 122 Pekanbaru. *Jurnal Ilmiah Kajian Multidisipliner, 8*(5), 819–826.

Mahjatia, N., Susilowati, E., & Miriam, S. (2021). Pengembangan LKPD Berbasis STEM untuk Melatihkan Keterampilan Proses Sains Siswa Melalui Inkuiri Terbimbing. *Jurnal Ilmiah Pendidikan Fisika*, *4*(3), 139. https://doi.org/10.20527/jipf.v4i3.2055

Mandolang, A. H., Rende, J. C., & Dilapanga, A. (2022). Pengembangan instrumen penilaian unjuk kerja dalam kegiatan praktikum pada pokok bahasan fluida dinamis kelas XI SMA. *Charmsains: Jurnal Pendidikan Fisika, 3*(1), 15–18.

Mu'minah, I. H., & Aripin, I. (2019). Implementasi STEM dalam pembelajaran abad 21. *Prosiding Seminar Nasional Pendidikan*, *1*, 1495–1503.

Mu'minah, I. H., & Suryaningsih, Y. (2020). Implementasi STEAM (Science, Technology, Engineering, Art and Mathematics) dalam pembelajaran abad 21. *Jurnal Bio Educatio*, *5*(1), 65–73.

Mustafa, P. S., & Dwiyogo, W. (2020). Kurikulum pendidikan jasmani, olahraga, dan kesehatan di Indonesia abad 21. *JARTIKA: Jurnal Riset Teknologi dan Inovasi Pendidikan, 3*(2), 422–438.

Mustafa, P. S., & Masgumelar, N. K. (2022). Pengembangan instrumen penilaian sikap, pengetahuan, dan keterampilan dalam pendidikan jasmani. *Biormatika: Jurnal Ilmiah Fakultas Keguruan dan Ilmu Pendidikan, 8*(1), 31–49.

Nuraeni, F., & Zahra, Z. N. (2021). Proyek desain rekayasa dalam pembelajaran IPA untuk meningkatkan *collaborative problem solving* dan pemahaman konsep. *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, 11(2), 47–59.

Nurhasanah, E., Uswatun, D. A., & Maula, L. H. (2019). Meningkatkan keterampilan proses sains melalui model pembelajaran inkuiri pada siswa di sekolah dasar. *Jurnal Perseda: Jurnal Pendidikan Guru Sekolah Dasar, 2*(3), 168–178.

Nurramadhani, A., Lathifah, S. S., & Permana, I. (2020). Students' generated questions quality by developing STEM-based e-module in science learning. *Scientiae Educatia: Jurnal Pendidikan Sains*, *9*(2), 134-152.

Nurramadhani, A., Permanasari, A., & Suwarma, I. R. (2024). STEM based Project Learning: How It Affects Preservice Science Teacher's Creativity Before, During, and After Pandemic Covid-19?. *EduMatSains: Jurnal Pendidikan, Matematika Dan Sains*, *9*(1), 29-39.

Putri, S. U. (2019). *Pembelajaran sains untuk anak usia dini*. UPI Sumedang Press.

Ratnawulan, E., & Rusdiana, A. (2014). *Evaluasi Pembelajaran*. Pustaka Setia.

Rendra, G. R. P., Darmawiguna, I. G. M., & Sindu, I. G. P. (2018). Pengembangan e-modul berbasis project based learning menggunakan Schoology (studi kasus mata pelajaran Web Design kelas XI Multimedia di SMK TI Bali Global Singaraja). *KARMAPATI: Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika, 7*(2), 50–58.

Santoso, A. M., & Arif, S. (2021). Efektivitas model inquiry dengan pendekatan STEM education terhadap kemampuan berfikir kritis peserta didik. *Jurnal Tadris IPA Indonesia*, *1*(2), 73–86.

Sarı, U., Duygu, E., Şen, Ö. F., & Kırındı, T. (2020). The Effects of STEM education on scientific process skills and STEM awareness in simulation based ınquiry learning environment. *Journal of Turkish Science Education*, *17*(3), 387-405.

Sugiyono. (2016). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Alfabeta.

Syukri, M., Herliana, F., Maryono, M., Ngadimin, N., & Artika, W. (2023). Development of physics worksheet based on STEM integrating Engineering Design Process (EDP) through guided inquiry model to improve students' critical thinking. *Jurnal Penelitian & Pengembangan Pendidikan Fisika, 9*(2), 225–236.

Thovawira, F. A., Safitri, I., Supartik, S., Sitompul, N. N. S., & Anggriyani, I. (2021). Systematic literature review: Implementasi pendekatan STEM (manfaat dan tantangan) di Indonesia. *HISTOGRAM: Jurnal Pendidikan Matematika, 4*(2), 355–371.

Ulum, M. B., Putra, P. D. A., & Nuraini, L. (2021). Identifikasi penggunaan EDP (Engineering Design Process) dalam berpikir engineer siswa SMA melalui lembar kerja siswa (LKS). *Jurnal Riset dan Kajian Pendidikan Fisika, 8*(2), 53–63.

Viswesvaran, C., & Ones, D. S. (2018). Non-test methods and techniques used in employee selection. In *The SAGE handbook of industrial, work and organizational psychology* (Vol. 1, pp. 451-473). Sage.

Wijaya, F. W., Taufiqqurrachman, T., & Sutisna, M. A. (2022). Pengembangan instrumen penilaian kinerja berbasis keterampilan proses sains pada materi getaran harmonis. *Experiment: Journal of Science Education, 2*(1), 19–28.

Yu, K.-C., Wu, P.-H., & Fan, S.-C. (2020). Structural relationships among high school students' scientific knowledge, critical thinking, engineering design process, and design product. *International Journal of Science and Mathematics Education, 18*(6), 1001–1022.

Yuliati, C. L., & Susianna, N. (2023). Penerapan model pembelajaran discovery learning dalam meningkatkan keterampilan proses sains, berpikir kritis, dan percaya diri siswa. *Scholaria: Jurnal Pendidikan dan Kebudayaan, 13*(1), 48–58.