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Development of a Science Process Skills Instrument for Ecology: A Validity and Reliability Study

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Abstract
This research uses the Theory-Based Instrument Development Model. This model develops an instrument based on existing theories to ensure that the instrument has a strong theoretical basis. The steps are determining relevant theories, compiling instrument items based on theoretical concepts, validating content with theoretical experts, and testing the reliability and validity of empirical evidence. To assess the content validity, the Content Validity Ratio (CVR) and Content Validity Index (CVI) methods are employed, along with evaluating item validity and reliability. The results highlight that the content validity, item validity, and reliability of the instruments developed are crucial components in the creation of assessment tools. The development of science process skills instruments holds significant value within the field of education, as it aids in measuring essential scientific abilities and promoting effective learning outcomes. This instrument helps in measuring students' ability to carry out scientific processes such as observing, classifying, measuring, communicating, inferring, predicting, identifying variables, using number, and using spice/time relation Integrated processes: formulating hypotheses, controlling variables, devining operationally, investigating and experimenting. In this study, the science process skill instrument developed obtained the result of content validity declared very valid (0.91) based on the CVR and CVI tests, and based on the empirical test of the validity of the item and reliability (0.940) , it was stated that 21 items of science process skills were in the valid and reliable category.

Keywords: Validity, Reliability, Instrument, Science process skills.

1. Introduction

Science process skills are fundamental abilities that are essential for the acquisition, development, and application of scientific concepts and principles (Darmaji, Astalini, et al., 2020; Darmaji et al., 2022; Darmaji, Kurniawan, et al., 2020). These skills include both basic science process skills, such as observing, inferring, measuring, communicating, classifying, and predicting, and integrated science process skills, which involve more complex tasks like creating graphs and analyzing relationships between variables (Darmaji et al., 2022; Kurniawati, 2021; Pohan et al., 2020). Mastery of these skills is vital for students, as they enable effective problem- solving, facilitate scientific inquiry, and contribute to the generation of new scientific knowledge (Ediyanto et al., 2018; Ongowo & Indoshi, 2013). The development of science process skills also plays a crucial role in scientific investigations, as these skills are necessary for framing research questions, collecting and analyzing data, and making evidence-based conclusions. Furthermore, these skills are indispensable for understanding complex scientific phenomena and conducting meaningful experiments. As such, integrating and nurturing science process skills within the curriculum is critical, not only for enhancing students' comprehension of scientific content but also for fostering their ability to engage in critical thinking and scientific exploration (Rinjani & Romadona, 2023). These competencies are indispensable for students' success in both academic and practical scientific endeavors.

Integrating the teaching of science content with science process skills is highly recommended, as these two elements complement each other and contribute to a deeper understanding of scientific principles (Chabalengula et al., 2012). Science process skills extend beyond cognitive abilities to include physical and social dimensions, which are crucial for helping students grasp abstract concepts through hands-on learning experiences (Darmaji, Astalini, et al., 2020; Darmaji et al., 2022; Darmaji, Kurniawan, et al., 2020). These skills are essential in enhancing students' problem-solving capabilities by guiding them to systematically search for, acquire, and process knowledge (Miranti et al., 2022). Ultimately, science process skills are indispensable for fostering a scientific mindset in students, enabling them to engage in scientific inquiry, and equipping them to effectively navigate the complexities of scientific learning and problem- solving. Thus, integrating these skills into education is crucial for helping students develop a comprehensive understanding of both science content and the scientific method.

In evaluating science process skills, the appropriate use of assessment instruments is crucial. The instrument must account for the type of response required, the level of difficulty, and the specific focus of the evaluation, whether it targets knowledge, skills, or attitudes (Supianto et al., 2023). Effective instruments should align with the indicators of mastery in the science process concepts and skills being evaluated, and they must be relevant to the learning activities conducted (Puteri et al., 2022). Commonly used instruments in this field include reasoned multiple-choice questions that measure specific indicators of science process skills, such as observing, predicting, hypothesizing, and communicating (Rani, 2019). In addition, instruments such as questions assessing Critical Thinking Skills and observation sheets for science process skills are commonly utilized to examine the correlation between these skills and students' critical thinking abilities (Purwanti & Heldalia, 2022). In this study, the developed instrument consists of essay questions designed to assess students' understanding and application of science process skills in an open- ended format. This method enables a more in-depth analysis of students' scientific reasoning and their problem-solving capabilities.

The aim of developing science process skills assessment instruments is to create valid and reliable tools for evaluating students' abilities in key science process skills such as predicting, controlling variables, interpreting, and communicating (Pradana et al., 2021). Teachers must also be proficient in designing effective learning experiences, developing the necessary assessment tools, and evaluating students' science process skills(Desideria et al., 2018). Research instruments can take the form of a rubric for science process skills, with a clear assessment scale, or a multiple-choice test to assess student learning outcomes (Deli et al., 2017). However, this study focuses on developing an essay-based science process skills instrument. Ensuring that these instruments are both valid and reliable is crucial for accurately capturing students' science process skills (Setiadi et al., 2020).

However, a critical review of existing assessment instruments for science process skills reveals several notable limitations. Most instruments currently available predominantly utilize multiple-choice formats, which, while practical for large-scale assessments, may not sufficiently capture the depth and quality of students' scientific reasoning. Such closed-ended instruments often fail to explore students' ability to construct arguments, explain their thought processes, or apply scientific concepts in novel contexts. Furthermore, there is a notable lack of open-ended, essay- based instruments that have been specifically validated for ecological content. Previous research has rarely addressed the development of essay-based assessment tools for science process skills in ecological education, leaving a gap in both practical application and empirical validation. As a result, teachers and researchers lack comprehensive tools that allow for in-depth evaluation of students' science process skills in contexts that demand explanation, justification, and the application of knowledge.

Therefore, this study aims to develop and validate an essay-based instrument for assessing students' science process skills in the context of ecological learning. By addressing the shortcomings of existing assessment formats, this research seeks to provide a more robust, valid, and reliable tool that can better evaluate students' scientific reasoning and problem-solving abilities in ecology education.

The development of science process skill instruments is of significant importance, particularly in the context of educational curricula for science subjects like biology (Sukma et al., 2022). These skills encompass various dimensions, including cognitive, manual, social, mental, and physical aspects, all of which are essential for effective learning, problem-solving, and both individual and group development (Dari & Nasih, 2020). Scientists rely on science process skills to generate knowledge, address challenges, and present findings (Mansur, 2021). Instruments designed to assess science process skills, such as Student Worksheets (LKS) with structured questions, are used to evaluate students' abilities to apply these skills (Susiwi & Hinduan, 2015). Additional research tools like the science process skills rubric and observation sheets have been employed to assess and quantify students' proficiency in these skills (Deli et al., 2017; Purwanti & Heldalia, 2022; Yuliati, 2016). Furthermore, the creation of valid and reliable assessment instruments is crucial for comprehensively measuring students' science process skills (Pradana et al., 2021).

In particular, science process skills not only support students' understanding of complex scientific concepts but also serve as a foundation for fostering a deeper connection with the material, encouraging analytical thinking, and enhancing problem-solving abilities. As students engage with science content through inquiry-based learning and hands-on activities, their capacity to think critically and apply scientific methods in real-world contexts is significantly improved. Given this, the development and validation of science process skills instruments become pivotal for advancing pedagogical practices aimed at cultivating a generation of learners proficient in both scientific knowledge and critical reasoning. Thus, the development of such assessment tools is not just beneficial but necessary for creating a learning environment that fosters critical thinking and scientific literacy, ensuring that students are equipped with the skills they need for both academic success and practical problem-solving in everyday life. The validity and reliability of these instruments are integral to their utility in ecology courses, providing educators with effective tools to gauge and enhance student performance in these crucial areas.

2. Methods

This research employed the Theory-Based Instrument Development Model. This model constructs instruments grounded in established theories to ensure a strong theoretical foundation. In this study, instrument development referred to the science process skills framework proposed by Rezba et al. (1995), which includes two categories: Basic processes: observing, classifying, measuring, communicating, inferring, predicting, identifying variables, using numbers, and using space/time relationships; and Integrated processes: formulating hypotheses, controlling variables, defining operationally, investigating, and experimenting. The development steps comprised identifying relevant theories, constructing instrument items based on theoretical concepts, validating the content with theoretical experts, and testing the instrument's reliability and empirical validity. Content validity was assessed by five experts in biology education, while the validity and reliability tests involved a sample of 31 participants. The science process skills instrument was developed for ecology lecture material in the fourth semester of the undergraduate Biology Education program.

2.1 Content Validity

To determine the validity of the content, the content validity ratio and content validity index methods are used (Lawshe, 1975). This method has been widely used to quantify content validity, making it one of the earliest and most popular approaches for this purpose (Wilson et al., 2012). Lawshe's Content Validity Ratio (CVR) method has been utilized in various fields, such as education, psychology, and healthcare, to ensure that the content of assessments, questionnaires, and instruments is relevant and appropriate for the intended purpose (Doğan & Özdemir, 2020; Silva et al., 2020; Zaidi et al., 2023). The method involves expert judgment to evaluate the adequacy of the content domain sampled, ensuring that the items included are pertinent to the targeted domain (Fitzpatrick, 1983; Guion, 1978). Minimum Values of CVR and CVR_t One

Tailed Test, p= ,05 with 5 panelist is 0,99.

$$CVR = \frac{n_e - N/2}{N/2}$$

CVR : *Content Validity Ratio*
n_e : the number *of panelists indicating "essential"*
N : total *number of panelists*

Determine the validity of the instrument by measuring the CVI *(Content Validity Index)*

$$CVI = \frac{\sum CVR}{k}$$

CVI : *Content Validity Index*
$\sum CVR$: Number of *Content Validity Ratio*
k : number/number of items

Table 1.
CVI Value Category

Range	Weight
.00 - .33	Not suitable/invalid
.34 - .67	Compliant/Valid
.68 - 1	Very Suitable/Very Valid

2.2 Item Validity

Then to conduct an empirical test of the validity of the item that was tested on biology education students in the 4th semester using the SPSS version 24 application by referring to the polytomy validity test with categorization referring to table 2 below (Guilford, 1950). In a development research, a product is considered feasible for use if it meets the validity criteria (Purnamasari & Setiyadi, 2019; Setiyadi, 2021)

Table 2.
Item Validity Criteria

Range	Criterion
.80 < XY ≤ 1	Very high validity
.60 < rXY ≤ .80	High Validity
.40 < rXY ≤ .60	Medium Validity
.20 < rXY ≤ .40	Low Validity
.00 < rXY ≤ .20	Invalid

2.3 Reliability

Reliability test criteria, the instrument is declared reliable if the crobat alpha alpha>60 value.

3. Results and Discussion

3.1. Result

3.1.1 Content Validity Results

The 14 indicators of science process skills are categorized into 9 basic process skills and 5 integrated skills. Each indicator is represented by two questions, resulting in a total of 28 questions to be tested. The validation results, based on calculations from five experts using the CVR and CVI methods, are presented in Table 3 below.

Table 3.

Results of content validity by 5 experts

Question Items	*the number of panelists indicating "non essential"*	*the number of panelists indicating "essential"*	CVR	Category	CVI	Category
Q1	-	5	1	Valid	0.91	Highly validity
Q2	-	5	1	Valid		
Q3	-	5	1	Valid		
Q4	-	5	1	Valid		
Q5	-	5	1	Valid		
Q6	-	5	1	Valid		
Q7	-	5	1	Valid		
Q8	1	4	.60	Invalid		
Q9	-	5	1	Valid		
Q10	-	5	1	Valid		
Q11	-	5	1	Valid		
Q12	-	5	1	Valid		
Q13	1	4	.60	Invalid		
Q14	-	5	1	Valid		
Q15	-	5	1	Valid		
Q16	2	3	.20	Invalid		
Q17	-	5	1	Valid		
Q18	-	5	1	Valid		
Q19	-	5	1	Valid		
Q20	-	5	1	Valid		
Q21	-	5	1	Valid		
Q22	-	5	1	Valid		
Q23	-	5	1	Valid		
Q24	-	5	1	Valid		
Q25	2	3	.20	Invalid		
Q26	-	5	1	Valid		
Q27	-	5	1	Valid		
Q28	-	5	1	Valid		

Based on the results of content validation of five experts using the CVR method, there were 24 question items that were declared valid and four sola items were declared invalid, but when viewed from the overall test content validity index instrument of the science process skills as a whole the questions can be declared very valid by judging the CVI categorization in table 1, which is 0.91. Of the 4 questions that were declared invalid, improvements were made according to the direction of the validator instrument so that the four items were included in the empirical test.

3.1.2 Item Validation Results

The results of the empirical test conducted on biology education students in the 4th semester with a sample of 31 people can be seen in table 4 below.

Table 4.
Results of Empiric Instrument Test of Science Process Skills

Question items	Pearson correlation	Category
Q1	.870	Very Valid
Q2	.825	Very Valid
Q3	.082	Invalid
Q4	.675	Valid
Q5	.825	Very Valid
Q6	.328	Invalid
Q7	.825	Very Valid
Q8	.784	Valid
Q9	.539	Medium
Q10	.735	Valid
Q11	.910	Very Valid
Q12	.910	Valid
Q13	.204	Invalid
Q14	.683	Valid
Q15	.869	Very Valid
Q16	.721	Valid
Q17	.869	Very Valid
Q18	.807	Very Valid
Q19	.556	Medium
Q20	.841	Very Valid
Q21	.485	Medium
Q22	.110	Invalid

Q23	.597	Medium
Q24	.082	Invalid
Q25	.148	Invalid
Q26	.408	Medium
Q27	.825	Very Valid
Q28	.117	Invalid

Based on table 5 of the results of the validation of question items, there are 7 questions that are classified as invalid and 21 questions that are included in the valid category. Then from the 21 questions that are categorized as valid continue to the next test, namely the reliability test of the following.

3.1.3 Question Reliability Test

After obtaining 21 questions that are declared valid, they will continue to be tested for reliability using the cronbach's Alpha test and get the following results

Table 5.
Reliability Statistics

Cronbach's Alpha	No Of Items
.940	21

Based on the results of the alpha cronbarch table, a result of 0.9410 was obtained. Reliability test criteria, the instrument is declared reliable if the crobat alpha alpha>60 value. So it can be concluded that the reliability test results of 21 questions that have been declared valid previously are reliable (0.940>0.60).

3.2 Discussion

Science process skills play a crucial role in science education and the development of students' scientific competencies. These skills are vital for engaging in scientific inquiry, problem-solving, critical thinking, and decision-making. Key aspects of science process skills encompass the ability to observe, classify, measure, communicate, infer, predict, identify variables, use numerical data, and comprehend spatial and temporal relationships (Widyaningsih et al., 2020). Research highlights that science process skills are not only fundamental for practicing science but also for enhancing students' grasp of scientific concepts and principles. These skills enable students to actively engage in learning, take ownership of their education, and refine their research methodologies (Inayah et al., 2020). Additionally, studies indicate that mastering science process skills leads to improvements in students' academic performance, critical thinking, and scientific literacy. These skills help students apply the scientific method effectively, develop and explore scientific knowledge, and enhance their problem-solving capabilities (Adah & Nsikhe, 2020; Perdana et al., 2022).

Science process skills also become the top subject matter in development of assessment instruments. Commonly, the research instruments used are science process skills tests with description questions, and observation sheets (Kurniawati, 2021). It indicates that capture of science process skills needed to be whole and varied to attain wholeness for students' skill development. Therefore, process skills in science are not only the intellectual capabilities but also involve the psychomotor and social aspects that are significant in learning science. When students can apply science process skills, they can understand scientific concepts, and these skills can make students develop critical problems-solveing skills that will help them to face problems in everyday life.

This is of great importance because the science process skills instruments provide an overview of the development of science process skills. The Science Process Skills Test (SPST), an indirect assessment tool developed by Germann (1989), is used to assess the students' abilities to perform scientific processes including asking questions, writing hypotheses and designing experiments, gathering data, interpreting conclusions and providing evidence. Not only applicable to the context of learning in the classroom but also helpful to solve the everyday problems (Inayah et al., 2020). According to Jack (2018) research on science process skills indicates that such skills have the potential to provide students with opportunities to build higher mental processes including problem-solving, critical thinking, and decision-making skills. It is supported by the results of research Adah & Nsikhe (2020) that a scientific approach program in science learning can enhance students ability of scientific process skills.

Works in research development showed that models in teaching science process skills, such as the REACT learning model or the POGIL learning model, were proven to improve students' literacy in science, collaborative skills, and learning outcomes (Hidayati & Purwaningsih, 2023; Puspitasari et al., 2024; Rahayu Fitri et al., 2023; Wulandari & Sari, 2023). Focusing on science process skills helps students become proficient in the uses of science: inquiry, the interpretation of data and the communication of science. Moreover, science process skills instruments can also be developed through other methods, such as STEM integrated project-based learning(Lumbantobing et al., 2022), inquiry learning approach (Germann, 1989), or the Science Technology Society approach (Muhibbuddin & Sari, 2019). In creating this instrument there are several stages that must be passed, namely theory synthesis, instrument design, validity, reliability, and item analysis (Tanfiziyah et al., 2021). By that means, science process skills instrument development is a significant role to increase students' skills in conducting scientific processes, listening to input in an approachable way, and most importantly to prepare students to face the real world.

This study uses a science process skill instruments which developed in the basis of the science process skills proposed by Rezba et al.Rezba et al. (1995) that consist of Basic processes: observing, classifying, measuring, communicating, inferring, predicting, identifying variable, using number, and using spice/time relation Integrated processes: formulating hypotheses, controlling variable, devining operationally, investigating and experimenting. Where each indicator will have two questions to be tested content, face and reliability When developing assessment instruments, it is important to ensure the validity of the content, the validity of the

items, and the reliability of the instruments developed. Content validity indicates how well the instrument covers all domains that are to be measured; item validity indicates how well each question item on the instrument measures the concept of interest. On the other hand, reliability of an instrument refers to the degree with which an instrument produces similar outcome if applied multiple times.

The validity of the content in the science process skills instrument is a critical component in the development of assessment tools. Content validity refers to the extent to which an assessment accurately measures the construct or skill it is intended to assess. It is crucial in ensuring that the instrument effectively evaluates the science process skills possessed by students, covering areas such as observing, classifying, measuring, communicating, interpreting, predicting, identifying variables, using numbers, and understanding spatial and temporal relationships in the context of science. The 28-question instrument underwent content validation to achieve a validity level of 0.90, employing the CVR (Content Validity Ratio) and CVI (Content Validity Index) methods with five experts in the field of biology education. The validation results indicated that 24 questions were deemed valid, while four items were considered invalid. The CVI was calculated at 0.91, confirming that the content validity of the developed science process skills instrument is very high. The four invalid items cannot be used, while two valid items require revision before implementation. A study by Astuti et al. supports this by demonstrating the development and validation of an integrated assessment instrument for measuring students' critical thinking and science skills. The study's findings affirm that while the instrument has been validated in terms of content and construct validity, content validity remains a key factor for the instrument's effectiveness. Therefore, the content validity of the science process skills instrument is a fundamental aspect to ensure that the instrument can reliably and accurately measure the intended skills (Astuti et al., 2022).

The content validity of every instrument item is the most important part of the development of science process skills assessment instruments. Item validity is the measure extent of how each question item on the instrument measures what it is intended to measure; that is, the concept or skill that is actually being tested. This can also be done by maintaining a good item validity which ensures all the questions in the instrument are relevant and appropriate to measure the desired science process skills. The rationale behind this research is that the validity of the item was only tested to a limited extent, namely 31 people consisted of 4th semester biology education students From the trial results of 31 students, it was found that of the 28 questions tested, 7 questions were declared invalid, 5 questions were placed in the medium category, 6 questions were declared valid and 10 questions were declared very valid, so that a total of 21 questions were declared valid. The analysis of the validity of this blue suggests that of the fourteen indicators of skill pose science there is at least one saol that represents.

Abstract Confirming the validity of instrument items is essential in developing science process skills assessment instruments. Hence, high item validity will give a high instrument reliabilitas and validity, so that the results of the science process skills measurement obtain are reliable and accurate. The item validity is one of the indicators to know whether the integrated assessment instrument of critical thinking skills and science process skills is suitable to use(Sari & Suyanta,

2021; Wulandari & Sari, 2023). To prove that each of question item is actually valid and strong enough to measures skills that need to be tested, they used the question item validation sheet as one of their data collection instruments. Likewise, Mustafa et al. (2021) For instance, (Kurniawati, 2021) highlight the significance of items validity instrument to ensure science process skills calibarates correctly among Malaysian primary school students. The Rasch analysis model was used to verify the validity of the items of the developed instrument, ensuring that every question item genuinely and accurately measured the skill being targeted.

In the development of assessment instruments for science process skills, instrument reliability is a crucial aspect. Reliability is the degree to which the instrument would return the same results if the same instrument is repeated multiple times. High reliability ensures that the instruments used for assessment could be depended upon to produce consistent and trustworthy outcomes. After being 21 questions were specified valid than the next 21 questions were tested validity. From the alpha cronbarch table, a value equal to zero point nine forty-one [0.9410] was obtained. Data analysis for the reliability test criteria the instrument has reported reliability if the crobat alpha alpha>60. It can be concluded that the reliability test results of 21 questions that have been declared reliable previously reliabel (0.940>0.60). Vargas et al. (2024) found the reliability of these instruments critical to establish a link between pedagogical content knowledge and professional practice around science teaching. The conclusion of this study demonstrates that a reliable tool enables teachers to reflect on pedagogical practices in the process of developing their teaching and learning processes with work practices, so that they can rethink and generate inputs that promote learning of the matters and the development of scientific skills and attitudes in students. Further, the study Tauhidah & Rofi'ah (2023) also highlights the significance of the instrument reliable to calibrating the science process skills skill test instruments for high school students. The analysis of Rasch model was used to study the reliability of developed instruments which ensured that the instruments are able to yield consistent and repeated findings. So, an instrument must be reliable or stable, that is, it should give the same result on every better re- examination over be and time (Andrian et al., 2018). The high reliability will result in the high reliability of instrument and ensure the result of the measurement of the science process skill gained is reliable.

Research by Suciati et al. (2020) The validity and reliability of instruments are crucial in the development of instruments for mathematics literacy students Indoneisa(Suciati et al., 2020) They used experts as instrument validators and student as participants. The results of this study indicate that the validity and reliability of the instrument are important in order to provide effectiveness in the use of these instruments. Furthermore, the study by Andrian et al. As confirmed by (Andrian et al., 2018), the instrument must also be content and construct validity and reliability, as both validity and reliability are integral to instrument development. This corresponds with the result from razali Razali et al. (2024) which reveals that the construct of cultural responsive leadership instruments has a high reliability value. Therefore, content validity, item validity and reliability of the instrument are issues that cannot be ignored in the development of assessment instruments. Having a well-validated and value-based instrument of the three ensures the reliability and the importance of using this construct. However, the study acknowledges a limitation in the relatively small sample size of 31 participants. Future research

should aim to expand the sample size to further validate the instrument and enhance its applicability. Overall, the results of this study underscore the importance of developing robust and reliable instruments for assessing science process skills, which are essential for promoting effective science learning.

4. Conclusion

The validity of content, item validity, and the reliability of assessment instruments are fundamental components in the development of effective educational tools. Content validity pertains to how thoroughly the instrument covers the various aspects of the concept it aims to measure, ensuring a comprehensive representation of the subject matter. Item validity, on the other hand, refers to the degree to which each individual item or question in the instrument effectively assesses the specific concept it is intended to measure. Reliability indicates the consistency of the instrument, meaning that it produces stable results when applied multiple times under similar conditions. These aspects are critical for ensuring that the instrument accurately measures the intended science process skills. In the context of science education, the development of science process skill instruments plays a crucial role in assessing students' ability to engage in various scientific processes. These processes include observing, classifying, measuring, communicating, inferring, predicting, identifying variables, using numbers, and understanding spatial and temporal relationships. Additionally, integrated science process skills, such as formulating hypotheses, controlling variables, defining operational terms, conducting investigations, and experimenting, are essential for fostering a deep understanding of scientific inquiry. In the present study, the science process skill instrument developed was found to have very high content validity (0.91) based on the Content Validity Ratio (CVR) and Content Validity Index (CVI) tests. Furthermore, empirical testing confirmed that 21 of the instrument's items were both valid and reliable, aligning with the established criteria for measuring science process skills.

5. Aknowledgments

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6. References

Adah, S., & Nsikhe, U. (2020). Interaction Effect of Selected Science Process Skills Acquisition on Students' Academic Performance in Practical Biology in Calabar Education Zone, Cross River State of Nigeria. *Journal of Education and Practice*. https://doi.org/10.7176/JEP/11-29-05

Andrian, D., Kartowagiran, B., & Hadi, S. (2018). The Instrument Development to Evaluate Local Curriculum in Indonesia. *International Journal of Instruction*, *11*(4), 921–934. https://doi.org/10.12973/iji.2018.11458a

Astuti, S. R. D., Sari, A. R. P., Amelia, R. N., & Karlinda, K. (2022). Instrumen Penilaian Terintegrasi : Pengukuran Kemampuan Berpikir Kritis Dan Keterampilan Sains Siswa Pada Materi Larutan Elektrolit Dan Nonelektrolit. *Jurnal Tarbiyah*, *29*(2), 340. https://doi.org/10.30829/tar.v29i2.1858

Chabalengula, V. M., Mumba, F., & Mbewe, S. (2012). How Pre-service Teachers' Understand and Perform Science Process Skills. *EURASIA Journal of Mathematics, Science and Technology Education*, *8*(3). https://doi.org/10.12973/eurasia.2012.832a

Dari, R. W., & Nasih, N. R. (2020). Analisis Keterampilan Proses Sains Mahasiswa Pada Praktikum Menggunakan E-Modul. *Edu Sains Jurnal Pendidikan Sains & Matematika*, *8*(2), 12–21. https://doi.org/10.23971/eds.v8i2.1626

Darmaji, D., Astalini, A., Kurniawan, D. A., Ningsi, A. P., Romadona, D. D., & Dari, R. W. (2020). Regression of Science Process Skills On Critical Thinking Skills In Two Junior High Schools In Jambi City. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *5*(3), 177. https://doi.org/10.26737/jipf.v5i3.1788

Darmaji, D., Astalini, A., Kurniawan, D. A., & Triani, E. (2022). The effect of science process skills of students argumentation skills. *Jurnal Inovasi Pendidikan IPA*, *8*(1), 78–88. https://doi.org/10.21831/jipi.v8i1.49224

Darmaji, D., Kurniawan, D. A., Astalini, A., Winda, F. R., Heldalia, H., & Kartina, L. (2020). The Correlation Between Student Perceptions of the Use of E-Modules with Students' Basic Science Process Skills. *JPI (Jurnal Pendidikan Indonesia)*, *9*(4), 719–729. https://doi.org/10.23887/JPI-UNDIKSHA.V9I4.28310

Deli, H. R., Purwanto, A., & Darwis, D. (2017). Pengaruh Model Pembelajaran Guided Inquiry Dipadu Two Stay Two Stray (TSTS) Terhadap Keterampilan Proses Sains Siswa Pada Materi Larutan Asam Basa Terintegrasi Pendidikan Lingkungan Hidup. *JRPK: Jurnal Riset Pendidikan Kimia*, *7*(2), 153–159. https://doi.org/10.21009/JRPK.072.09

Desideria, S., Dj, L., & Zainul, R. (2018). *Deskripsi Keterampilan Proses Sains Peserta Didik Kelas XI IPA pada Materi Larutan Penyangga di SMAN 15 Padang*. https://doi.org/10.31227/osf.io/t5q89

DOĞAN, F., & ÖZDEMİR, B. (2020). Developing an Achievement Test about 7th Grade "Solar System and Beyond" Unit: Analysis of Validity and Reliability. *Journal of Computer and Education Research*, *8*(16), 476–502. https://doi.org/10.18009/jcer.719913

Ediyanto, E., Atika, I., Hayashida, M., & Kawai, N. (2018). A Literature Study of Science Process Skill toward Deaf and Hard of Hearing Students. *Proceedings of the 1st Annual International Conference on Mathematics, Science, and Education (ICoMSE 2017)*. https://doi.org/10.2991/icomse-17.2018.23

Fitzpatrick, A. R. (1983). The Meaning of Content Validity. *Applied Psychological*

Measurement, *7*(1), 3–13. https://doi.org/10.1177/014662168300700102

Germann, P. J. (1989). Directed-inquiry approach to learning science process skills: treatment effects and aptitude-treatment interactions. *Journal of Research in Science Teaching*, *26*(3), 237–250. https://doi.org/10.1002/tea.3660260305

Guilford, J. P. (1950). *Fundamental Statistics in Psychology and Education*. Mc Graw-Hill Book Co. Inc.

Guion, R. M. (1978). Scoring of content domain samples: The problem of fairness. *Journal of Applied Psychology*, *63*(4), 499–506. https://doi.org/10.1037/0021-9010.63.4.499

Hidayati, T., & Purwaningsih, D. (2023). The Effect of Applying Problem-Based Learning Model on Students' Critical Thinking Ability Science Subjects in Grade V Elementary School. *JPI (Jurnal Pendidikan Indonesia)*, *12*(3), 576–585. https://doi.org/10.23887/jpiundiksha.v12i3.55235

Inayah, A. D., Ristanto, R. H., Sigit, D. V., & Miarsyah, M. (2020). Analysis of Science Process Skills in Senior High School Students. *Universal Journal of Educational Research*, *8*(4A), 15–22. https://doi.org/10.13189/ujer.2020.081803

Jack, G. U. (2018). Chemistry Students' Science Process Skills Acquisition: Influence of Gender and Class size. *Global Research in Higher Education*, *1*(1), 80. https://doi.org/10.22158/grhe.v1n1p80

Kurniawati, A. (2021). Science Process Skills and Its Implementation in the Process of Science Learning Evaluation in Schools. *Journal of Science Education Research*, *5*(2), 16–20. https://doi.org/10.21831/jser.v5i2.44269

Lawshe, C. H. (1975). A Quantitative Approach To Content Validity. *Personnel Psychology*, *28*(4), 563–575. https://doi.org/10.1111/j.1744-6570.1975.tb01393.x

Lumbantobing, S. S., Faradiba, F., Prabowo, D. J., Sianturi, M., & Guswantoro, T. (2022). The Effect of Project Based Learning Integrated STEM to Increase Science Process Skill. *Jurnal Pendidikan Fisika Dan Teknologi*, *8*(2), 299–305. https://doi.org/10.29303/jpft.v8i2.4439

Mansur, S. (2021). Penerapan Metode Inkuiri Terbimbing Terhadap Keterampilan Proses Sains dan Hasil Belajar Siswa SMP. *Diklabio: Jurnal Pendidikan Dan Pembelajaran Biologi*, *5*(2), 140–146. https://doi.org/10.33369/diklabio.5.2.140-146

Miranti, D. N., Harjono, A., & Rahayu, S. (2022). Students problem-solving skills ability on work and energy topics with different science process skills using a problem-based learning model. *Jurnal Pijar Mipa*, *17*(5), 604–608. https://doi.org/10.29303/jpm.v17i5.3171

Mohd Razali, M. N., A. Hamid, A. H., Alias, B. S., & Mansor, A. N. (2024). The validity and reliability of culturally responsive leadership practice instruments in small schools peninsular Malaysia. *International Journal of Evaluation and Research in Education (IJERE)*, *13*(1), 1. https://doi.org/10.11591/ijere.v13i1.26274

Muhibbuddin, & Sari, I. W. M. (2019). Science Technology Society Approach Application On Students Literacy And Process Skills Of Science To

Study Dynamic Fluids. *Ijaedu- International E-Journal of Advances in Education*, 187–193. https://doi.org/10.18768/ijaedu.593494

Mustafa, N., Khairani, A. Z., & Ishak, N. A. (2021). Calibration of the science process skills among Malaysian elementary students: A Rasch model analysis. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(4), 1344. https://doi.org/10.11591/ijere.v10i4.21430

Ongowo, R. O., & Indoshi, F. C. (2013). Science Process Skills in the Kenya Certificate of Secondary Education Biology Practical Examinations. *Creative Education*, *04*(11), 713–717. https://doi.org/10.4236/ce.2013.411101

Perdana, R., Asrial, & Maison. (2022). The Impact of Student Motivation on Students' Science Process Skills. *Journal of Education Research and Evaluation*, *6*(4), 729–738. https://doi.org/10.23887/jere.v6i4.52350

Pohan, S. A., Widhiyanti, T., Mulyani, S., & Wiji, W. (2020). Intertextual-Based Learning Strategy in Salt Hydrolysis Concept to Promote Students' Concept Mastery and Scientific Process Skills. *Proceedings of the 4th Asian Education Symposium (AES 2019)*. https://doi.org/10.2991/assehr.k.200513.018

Pradana, D., Mahanal, S., & Nida, S. (2021). Pengembangan instrumen tes keterampilan proses sains pada materi kalor dan perpindahannya. *Jurnal MIPA Dan Pembelajarannya*, *1*(2), 121–128. https://doi.org/10.17977/um067v1i2p121-128

Purnamasari, S., & Setiyadi, M. W. (2019). Pengaruh Zat Kimia Pada Berbagai Suhu Terhadap Denyut Jantung Katak (Rana Sp.) Dalam Upaya Pengembangan Buku Petunjuk Praktikum Fisiologi Hewan. *Bioscientist : Jurnal Ilmiah Biologi*, *7*(2), 123. https://doi.org/10.33394/bjib.v7i2.2388

Purwanti, E., & Heldalia, H. (2022). Korelasi Keterampilan Proses Sains Dengan Kemampuan Berpikir Kritis Siswa Pada Materi Pemantulan Pada Cermin Datar. *Journal Evaluation in Education (JEE)*, *1*(4), 143–148. https://doi.org/10.37251/jee.v1i4.146

Puspitasari, P. A., Hastuti, B., & Mulyani, B. (2024). Impacts of The POGIL Learning Model Combined With a SETS Approach on Chemical Literacy and Science Process Skills in The Context of Buffer Solutions. *JKPK (Jurnal Kimia Dan Pendidikan Kimia)*, *9*(1), 171. https://doi.org/10.20961/jkpk.v9i1.85057

Puteri, R. P. I., Mulyani, S., Khoerunnisa, F., & Wiji, W. (2022). Strategi Pembelajaran Intertekstual Dengan Pogil Yang Berpotensi Meningkatkan Penguasaan KONSEP PENGARUH KONSENTRASI DAN SUHU TERHADAP LAJU REAKSI SERTA KPS siswa. *Jurnal Riset Dan Praktik Pendidikan Kimia*, *9*(2), 206–217. https://doi.org/10.17509/jrppk.v9i2.52263

Rahayu Fitri, Nasir, M., & Fakhruddin. (2023). Efforts to Improve Science Process and Collaboration Skills with the Implementation of the REACT Learning Model on Students. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8301–8307. https://doi.org/10.29303/jppipa.v9i10.5170

Rani, I. M. (2019). Analisis Keterampilan Proses Sains Peserta Didik Sma Kelas X Di Kecamatan Seberang Ulu I Dan Kertapati Palembang. *Jurnal Biologi Dan Pembelajarannya (JB&P)*, *6*(1). https://doi.org/10.29407/jbp.v6i1.12515

Rezba, R. J., & Sprague Constance S. (1995). *Learning and Assesing: SCIENCE PROCESS SKILLS* (4th ed.). Kendall/ Hunt Publishing Company. .

Rinjani, R., & Romadona, D. D. (2023). A Study of Student Science Process Skills: In Formal Change Practices. *Schrödinger: Journal of Physics Education*, *4*(2), 41–46. https://doi.org/10.37251/sjpe.v4i2.503

Sari, A. R. P., & Suyanta, S. (2021). Karakteristik instrumen integrated assessment untuk mengukur critical thinking skills dan science process skills. *Measurement In Educational Research (Meter)*, *1*(1), 26. https://doi.org/10.33292/meter.v1i1.108

Setiadi, D., Jufri, A. W., Ramdani, A., Jamaluddin, J., & Bachtiar, I. (2020). Pengembangan Bahan Ajar dan LKPD IPA untuk Meningkatkan Kompetensi Literasi Sains Bagi Guru Anggota MGMP IPA SMP di Kota Mataram. *Jurnal Pengabdian Magister Pendidikan IPA*, *2*(2). https://doi.org/10.29303/jpmpi.v2i2.372

Setiyadi, M. W. (2021). Pengembangan Lembar Kerja Peserta Didik Berbasis Learning Cycle (7E) pada Materi Plantae. *Jurnal Pijar Mipa*, *16*(2), 186–190. https://doi.org/10.29303/JPM.V16I2.2304

Silva, L. I. de C., Nascimento, D. C. de O., & Shimoda, E. (2020). Validity of items and Identification of aspects to be improved based on the Client Perception in a Surgery Clinic using the Lawshe Method. *International Journal of Advanced Engineering Research and Science*, *7*(12), 241–256. https://doi.org/10.22161/ijaers.712.36

Suciati, S., Munadi, S., Sugiman, S., & Febriyanti, W. D. R. (2020). Design and Validation of Mathematical Literacy Instruments for Assessment for Learning in Indonesia. *European Journal of Educational Research*, *volume-9-2020*(volume-9-issue-2-april-2020), 865–875. https://doi.org/10.12973/eu-jer.9.2.865

Sukma, N. K., Daud, F., & Faisal, F. (2022). Analisis Tugas Pembelajaran Berorientasi Keterampilan Proses Sains Pada Buku Teks Biologi Kelas X SMA. *Jurnal IPA Terpadu*, *6*(3), 38. https://doi.org/10.35580/ipaterpadu.v6i3.39016

Supianto, S., Marmoah, S., Poerwanti, J. I. S., Sukarno, S., Istiyati, S., & Mahfud, H. (2023). Workshop Peyusunan Instrumen Tes Bagi Guru Sekolah Dasar. *Adimas: Jurnal Pengabdian Kepada Masyarakat*, *7*(2), 117–124. https://doi.org/10.24269/adi.v7i2.7323

Susiwi, M., & Hinduan, A. (2015). Analisis Keterampilan Proses Sains Siswa Sma Pada "Model Pembelajaran Praktikum D-E-H." *Jurnal Pengajaran Matematika Dan Ilmu Pengetahuan Alam*, *14*(2), 87. https://doi.org/10.18269/jpmipa.v14i2.320

Syed Faiyaz Ahmad Zaidi, Dr. Naeem Ullah, Dr. Muhammad Kamran, & Javeria Urooj. (2023). School Leadership Scale for Teachers' Pedagogical Competence (SLSS-TPC): Designing and Validity Evaluation. *EDUCATIONAL RESEARCH AND INNOVATION*, *3*(2), 194–210. https://doi.org/10.61866/eri.v3i2.69

Tanfiziyah, R., Akbar, B., & Anugerah, D. (2021). Development instrument science process skills biology for Junior High School. *Edubiotik : Jurnal Pendidikan, Biologi Dan Terapan*, *6*(01), 58–65. https://doi.org/10.33503/ebio.v6i01.884

Tauhidah, D., & Rofi'ah, N. L. (2023). Validation of undergraduate science process skills tests: Rasch model analysis. *Research and Development in Education (RaDEn)*, *3*(1), 51–57. https://doi.org/10.22219/raden.v3i1.24585

Vargas, S. D., Bernal-Ballén, A., Briceño-Martínez, J. J., & Ariza-Bareño, Y. (2024). Design and validation of an instrument to determine the relationship between pedagogical content knowledge and practical work in science instruction. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(1), em2382. https://doi.org/10.29333/ejmste/13962

Widyaningsih, D. A., Gunarhadi, & Muzzazinah. (2020). Analysis of Science Process Skills on Science Learning in Primary School. *Proceedings of the 3rd International Conference on Learning Innovation and Quality Education (ICLIQE 2019)*. https://doi.org/10.2991/assehr.k.200129.085

Wilson, F. R., Pan, W., & Schumsky, D. A. (2012). Recalculation of the Critical Values for Lawshe's Content Validity Ratio. *Measurement and Evaluation in Counseling and Development*, *45*(3), 197–210. https://doi.org/10.1177/0748175612440286

Wulandari, F., & Sari, P. P. (2023). The effect of project-based learning integrated STEM toward science process skill of elementary school student. *Jurnal Pijar Mipa*, *18*(3), 362–368. https://doi.org/10.29303/JPM.V18I3.4943

Yuliati, Y. (2016). Peningkatan Keterampilan Proses Sains Siswa Sekolah Dasar Melalui Model Pembelajaran Berbasis Masalah. *Jurnal Cakrawala Pendas*, *2*(2). https://doi.org/10.31949/jcp.v2i2.335