RESEARCH ARTICLE

Validating instrument to assess science literacy and independent learning skills in high school

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Abstract: Inadequate science literacy and independent learning hinder students' ability to analyze scientific information. This study aimed to develop and validate a measurement instrument to assess science literacy and independent learning skills among high school students. The instrument was piloted with 20 twelfth-grade students at SMAN 03 Kota Yogyakarta to assess its reliability and validity. The validated instrument was administered to 20 eleventh-grade students at the same school to identify the profiles of these two skills and explore their relationship in the context of the nervous system. The validity analysis demonstrated that both the science literacy and independent learning instruments exhibited strong validity. Pearson correlation analysis revealed that 20 items in the independent learning questionnaire were strongly correlated with the total score. Rasch analysis of the science literacy test indicated low infit mean square values, appropriate p-values, and high point biserial values, suggesting well-functioning items. Cronbach's alpha reliability coefficients for both instruments were excellent. The profile analysis revealed a discrepancy, with many students showing high independent learning levels but low science literacy scores on the nervous system topic. This gap suggests that even students capable of independent learning may face challenges in grasping specific scientific concepts.

Keywords: independent learning; science literacy; nervous system

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Introduction

The 21st century is characterized by rapid technological advancements, globalization, and an ever-increasing flow of information. In this dynamic environment, individuals face a myriad of challenges and opportunities that require a diverse set of skills and competencies. Among these essential skills, literacy and independent learning stand out as crucial for success in both personal and professional spheres. Literacy, encompassing both reading and writing skills, is the bedrock upon which individuals build knowledge, understanding, and critical thinking abilities (Farhat, 2021). It empowers them to access, comprehend, and communicate information effectively, enabling them to navigate the complexities of the modern world. In the context of the 21st century, literacy has evolved beyond traditional notions of reading and writing to encompass digital literacy, media literacy, and information literacy (Livingstone, 2004). These expanded forms of literacy are essential for individuals to critically evaluate information sources, engage in responsible online behavior, and effectively utilize technology for learning and communication. However many high school students struggle to comprehend complex scientific concepts, particularly in the field of neuroscience (Dubinsky et al., 2022).
Independent learning, the ability to take ownership of one's learning journey, is another critical skill for thriving in the 21st century (Al-Ajmy & Al-Mutairi, 2023). It empowers individuals to set their own learning goals, manage their time effectively, seek out and evaluate information, and apply their knowledge to

solve problems and make informed decisions. Independent learners are self-motivated, resourceful, and adaptable, capable of navigating the ever-changing landscape of knowledge and skills required for success in the modern world (Pyle, 2017). Science literacy, the ability to understand and apply scientific concepts, principles, and processes, is particularly crucial in the 21st century, characterized by scientific and technological advancements that impact every aspect of our lives. Scientifically literate individuals can critically evaluate scientific information, make informed decisions based on evidence, and engage in informed discussions about scientific issues. They are equipped to contribute to a society increasingly shaped by scientific knowledge and technology.

Literacy and independent learning are not isolated skills but rather interconnected threads that weave together to form a tapestry of lifelong learning. Literacy provides the tools to access and process information, while independent learning empowers individuals to take ownership of their learning journey and apply their literacy skills effectively (Horton, 2007). Together, they enable individuals to navigate the vast ocean of knowledge, adapt to new challenges, and continuously expand their understanding of the world around them.

A lack of independent learning can significantly impact various aspects of a student's development. Students who struggle to learn independently often rely on teachers or peers to complete assignments or grasp new concepts (Eberle & Hobrecht, 2021), hindering their ability to think critically and solve problems on their own, which can also lower their self-esteem (Wege et al., 2022). Coupled with this is a lack of motivation (Filgona et al., 2020), often leading to poor academic performance (Hockings et al., 2018). Furthermore, low science literacy compounds these issues. Students with limited science knowledge often struggle to think critically (Jurecki & Wander, 2012), making it difficult for them to understand environmental and social issues (Sharon & Baram-Tsabari, 2020; Valladares, 2021). They are also more likely to believe misinformation or fake news (He et al., 2021).

To date, there have been several studies aimed at developing instruments to measure scientific literacy and independent learning skills. Both of these instruments are important for evaluating students' competencies in the current 21st century. The development of such instruments often adapts existing development models, such as the Borg and Gall model or the PISA framework and Bloom's taxonomy (Faisal et al., 2023; Wati et al., 2023). Several studies have developed scientific literacy instruments for chemistry (Faisal et al., 2023) and physics subjects (Wati et al., 2023). On the other hand, other studies have also developed instruments to measure independent learning skills, although in the form of self-assessment tools (Belawati et al., 2023) and questionnaires (Rahmawati et al., 2022). Most of these studies do not develop both at once and use them directly to map the profiles of both skills at the same time. Therefore, the purpose of this study is to develop an instrument to measure both skills, especially in biology subjects. Furthermore, the two instruments developed are used to measure and map the skills of high school students.

Method

This study adopted the 4D development method to develop and validate science literacy and independent learning instruments (Thiagarajan et al., 1974). with a focus on the nervous system, a topic often found challenging by students. The first stage, Define, involved analyzing the 2013 biology curriculum to identify the scope and content of the nervous system topic. This stage also involved several steps including in-depth interviews with biology teachers who taught the nervous system to gain a deeper understanding of instructional emphasis, common student difficulties (like independent learning and scientific literacy from teachers' perspective), prevalent teaching methods. Continued by direct observation of syllabi and lesson plans related to the nervous system to identify core competencies, achievement indicators, and relevant teaching materials. Through this analysis, a clear understanding emerged regarding the scope and depth of the nervous system content. The design stage, entailed creating a grid of indicators for science literacy instrument items and independent learning questionnaire statements. The science literacy instrument was arranged based on PISA 2018 indicators to measure students' abilities. Coppi et al. (2023) described into sub-indicators based on nervous system content on the national curriculum standards outlined in Table 1. Meanwhile, the grid for the independent learning instrument is presented in Table 2.

The instrument was developed through a two-step process and revision in each process. First, expert lecturers conducted constructive validation to ensure alignment with the theoretical framework of instrument. Constructive validation by expert lecturers was employed to evaluate the 20 science literacy test items and 25 independent learning questionnaire items based on content of indicator, item construction with rating scale, and language clarity. The validation process involved one revision cycle to address typos and adjust cognitive levels, resulting in instruments deemed suitable for piloting. Then, a small-scale piloting with 20 participants from 12th grade science students at SMAN 03 Yogyakarta was conducted to obtain empirical evidence for the instrument's validity and reliability. The data from the small-scale piloting was analyzed statistically using SPSS and QUEST software to calculate validity and reliability scores for each instrument. The results of this analysis were used to revise invalid items on the science literacy test and independent learning questionnaire to improve them until they were valid. Disseminate stage involved measuring science literacy and independent learning abilities. A quantitative research approach was adopted to investigate the level of science literacy of 11th grade students in the subject of biology, topic of the nervous system. The study was conducted in 11th grade science class at SMA Negeri 3 Yogyakarta with a sample of 20 students. Data were collected using the science literacy and independent learning using the validated and reliable instruments. The data were analyzed using to determine the level of science literacy of the students based on Table 3 (science literacy variable) and Table 4 (independent learning variable).

Table 1. The Grid of science literacy indicators from PISA 2018 (Coppi et al., 2023)

The science literacy indicators	Sub Indicator	Items
Explaining phenomena in a fundamental and scientific manner	Recalling and applying scientific knowledge accurately to Parkinson's disease phenomena related to the central nervous system.	1
	Identifying explanations for examples of neurons and dopaminergic neurons in the nervous system	2
	Making accurate scientific predictions regarding the phenomenon of anesthesia mechanisms in the peripheral nervous system.	2
	Formulating and proposing hypotheses for the phenomenon of impulse transmission in the nervous system.	1
	Explaining the potential implications for society of impulse transmission phenomena and the role of conscious and unconscious movement mechanisms in the nervous system.	2
Designing scientific inquiry procedures	Identifying the given questions regarding the influence of food nutrition on the nervous 1system.	2
	Distinguishing between true and false scientific inquiries into various nervous system disorders.	1
	Arranging scientific methods to investigate the given questions in articles about various nervous system disorders.	1
Interpreting data based on scientific evidence	Analyzing empirical data to draw appropriate conclusions about nervous system phenomena.	1
	Identifying assumptions, evidence, and reasoning in texts about factors affecting the nervous system during development. phase	2
	Differentiating between health claims based on scientific evidence and theories based on other considerations in the context of nervous system phenomena.	1
Propose solutions to problems related to local, national, and global issues	Finding long-lasting ways to fix problems with our nerves in our community and around the world.	2
	Checking if these long-lasting solutions work to fix problems with our nerves in our community and around the world.	2

Table 2. The grid of independent learning aspect (Aini, 2021)

Aspect	Items
Self-reliance	5
Showing initiative	4
self-discipline	3
self-responsibility	5
Self-confident	3
Self-regulation	5

The research is expected to produce a valid and reliable science literacy and independent learning instrument that can be used to measure the science literacy and independent learning abilities of high school students. Additionally, the study will provide insights into the level of science literacy of grade 11th students in the subject of biology, topic of the nervous system. These findings can contribute to a better understanding of the connection between science literacy and students' ability to learn independently.

Table 3. Criteria for assessing students' science literacy skills (Ridwan & Ramdhan, 2021)

Interval	Criteria
86%-100%	Very Good
76%-85%	Good
60%-75%	Satisfactory
55%-59%	Needs Improvement
≤ 54%	Not Good

Table 4. Criteria of assessing students' independent learning (Hendrayana, 2014)

Interval	Criteria
85%-100%	Very High
69%-84%	High
53%-68%	Middle
37%-52%	Low
≤ 36%	Very Low

Results and Discussion

The validation of the independent learning instrument using Pearson's correlation coefficient and SPSS 26 is an important step in ensuring the quality of the instrument and the accuracy of the data it collects (Aithal & Aithal, 2020). A valid instrument can provide valuable information about students' independent learning and can be used to make informed decisions about instruction and intervention. Based on the results of empirical validation, the validity and reliability values of the learning independency instrument are in Table 5.

Table 5. Pearson test output of learning independency instrument

Item	*R-value*	*Sig.*	Validity
1	0.532	0.005	**VALID**
2	0.457	0.043	**VALID**
3	0.542	0.014	**VALID**
4	0.577	0.000	**VALID**
5	0.603	0.005	**VALID**
6	0.492	0.000	**VALID**
7	0.485	0.192	**VALID**
8	0.612	0.000	**VALID**
9	0.469	0.149	**VALID**
10	0.591	0.001	**VALID**
11	0.568	0.009	**VALID**
12	0.612	0.004	**VALID**
13	0.600	0.005	**VALID**
14	0.673	0.001	**VALID**
15	0.663	0.001	**VALID**
16	0.834	0.00	**VALID**
17	0.729	0.001	**VALID**
18	0.445	0.085	**VALID**
19	0.517	0.02	**VALID**
20	0.819	0.00	**VALID**
21	0.619	0.004	**VALID**
22	0.511	0.021	**VALID**
23	0.530	0.016	**VALID**
24	0.668	0.001	**VALID**
25	0.485	0.03	**VALID**

Pearson's Product-Moment Correlation Coefficient (r) is a statistical method used to measure the strength and direction of the relationship between two quantitative variables (Franzese & Iuliano, 2018). This test is often used in research to determine whether two variables are related to each other. Pearson's Product-Moment Correlation Coefficient can be used to assess the validity or suitability of a questionnaire/survey instrument (Zadworna et al., 2023), that used to measure the independent learning of students and obtain data from respondents. The Pearson Validity Test is a useful tool for testing the correlational validity of research instruments. Based on the results of the Pearson test (validity) from 20 respondent, it was found that out of the 25 questionnaire items, all items have an r-hit value below 0.444 and a significance value below the significance level of 0.05. Therefore, these 25 items are valid for use as a independent learning measurement instrument. The results of the Pearson Validity Test indicate that all 25 questionnaire items have a strong correlation with the overall measure of independent learning. This suggests that the items are measuring the same construct (independent learning) and are therefore valid for use in assessing students' independent learning.

The validity of the questionnaire items is an important consideration for ensuring the reliability and accuracy of the data collected (Karunarathna et al., 2024). Valid items will produce more consistent and meaningful results, which can be used to make informed decisions about student learning and intervention strategies. In addition to assessing the validity of individual items, it is also important to examine the overall internal consistency of the questionnaire. This can be done using measures such as Cronbach's alpha, which assesses the extent to which the items are measuring the same construct.It is also important to consider the external validity of the questionnaire, which refers to the extent to which the results can be generalized to other populations or settings. This can be done by comparing the results of the questionnaire to other measures of independent learning or by conducting studies in different contexts. Pearson's Product-Moment Correlation Coefficient is a valuable tool for assessing the validity of questionnaire items. The results of the Pearson Validity Test in this context suggest that the questionnaire items are valid for measuring the independent learning of students. However, it is important to consider other aspects of validity, such as internal consistency and external validity, to ensure the overall quality of the questionnaire.

The science literacy instrument underwent empirical validity assessment using the QUEST application. The results, including infit mean square values, p-values (difficulty levels), and point biserial values (discriminatory power), are presented in Table 6. Infit mean square measures the fit of each item to the overall model (Smith et al., 2008). Low infit mean square values indicate good item fit, while high values suggest potential item issues. P-values (difficulty levels) indicate the difficulty of each item. Low p-values suggest items are too easy, while high p-values suggest items are too difficult. Point biserial (discriminatory power) assesses each item's ability to distinguish between high- and low-scoring respondents (Essen & Akpan, 2018). High point biserial values indicate good discrimination, while low values suggest items may not be useful.

Table 6. Presents the infit mean square, p-value, and point biserial values for each item on the science literacy instrument

Item	p-value	Difficulty Level	Point Biserial	Discriminatory Power
1	0.69	Medium	0.21	Decent
2	0.00	Difficult	0.69	Pretty Good
3	0.002	Difficult	0.40	Pretty Good
4	0.002	Difficult	0.40	Pretty Good
5	0.123	Easy	0.36	Pretty Good
6	0.00	Difficult	0.73	Pretty Good
7	0.00	Difficult	0.46	Pretty Good
8	0.00	Difficult	0.52	Pretty Good
9	0.001	Difficult	0.41	Pretty Good
10	0.5	Medium	0.40	Pretty Good
11	0.00	Difficult	0.53	Pretty Good
12	0.00	Difficult	0.59	Pretty Good
13	0.00	Difficult	0.70	Pretty Good
14	0.00	Difficult	0.54	Pretty Good
15	0.00	Difficult	0.46	Pretty Good
16	0.026	Difficult	0.24	Decent
17	0.00	Difficult	0.66	Pretty Good
18	0.001	Difficult	0.41	Pretty Good
19	0.001	Difficult	0.43	Pretty Good
20	0.00	Difficult	0.47	Pretty Good

The reliability of the independent learning and science literacy instrument was assessed using Cronbach's alpha by SPSS 26, a statistical measure of internal consistency reliability. Internal consistency reliability refers to the extent to which the items on an instrument measure the same construct (Shrestha, 2021). Cronbach's alpha is a widely used method for assessing the internal consistency reliability of an instrument (Tavakol & Dennick, 2011; Wadkar et al., 2016). It calculates a coefficient (alpha) that ranges from 0 to 1, with higher values indicating greater internal consistency. A Cronbach's alpha coefficient value of 0.70 or higher is generally considered acceptable for research purposes. The purpose of assessing the reliability of the independent learning instrument is to determine whether the scores on the instrument are consistent and dependable. A reliable instrument should produce consistent results when administered repeatedly to the same individuals under similar

conditions (Clark & Watson, 1995).
In this context, the statement indicates that a Cronbach's alpha coefficient greater than 0.6 is considered acceptable for the independent learning instrument. This suggests that the instrument has an acceptable level of internal consistency, meaning that the items on the instrument are measuring the same construct of independent learning. A reliable independent learning instrument can provide valuable insights into students' independent learning over time (Pandiangan, 2023). Consistent scores can be used to track individual progress, identify areas for improvement, and evaluate the effectiveness of instructional interventions.
It is important to note that reliability is not a static property of an instrument. It can be influenced by factors such as the sample of respondents, the administration conditions, and the context in which the instrument is used. Therefore, it is important to periodically re-evaluate the reliability of an instrument to ensure its continued effectiveness. The assessment of the reliability of the independent learning instrument using Cronbach's alpha is an important step in ensuring the quality of the instrument and the consistency of its results. A reliable instrument can provide valuable information about students' learning outcome and can be used to make informed decisions about instruction and intervention (Reynders et al., 2020). Based on the results of the Cronbach's alpha reliability test for the independent learning instrument from SPSS, the following results were obtained, as shown in Table 7.

Table 7. Reliability statistic for independent learning and science literacy instrument

Statistic Result	Independent Learning Instrument	Science Literacy Instrument
N Item	25 Item	20
Cronbach's Alpha Coefficient	0.880	0.815
Reliability Status	Acceptable	Acceptable

Table 8. Profiles of independent learning and science literacy of 11th grade on nervous system

Respondent	Independent learning		Science Literacy	
	Score	Criteria	Score	Criteria
1	96	Very High	20	Not Good
2	84	High	16	Not Good
3	75	High	36	Not Good
4	74	High	48	Not Good
5	80	High	44	Not Good
6	70	High	36	Not Good
7	63	Middle	36	Not Good
8	80	High	40	Not Good
9	70	High	60	Satisfactory
10	68	Middle	72	Satisfactory
11	74	High	36	Not Good
12	60	Middle	48	Not Good
13	66	Middle	68	Satisfactory
14	75	High	28	Not Good
15	67	Middle	60	Satisfactory
16	73	High	28	Not Good
17	70	High	48	Not Good
18	67	Middle	72	Satisfactory
19	67	Middle	56	Need Improvement
20	70	High	76	Good

Following the validation and reliability assessment of the science literacy and independent learning instruments, a pilot test was conducted at SMAN 3 Yogyakarta. The results, presented in the following table, provide profiles of independent learning and science literacy. Pilot testing is a crucial step in instrument development to evaluate its effectiveness and identify potential issues before large-scale implementation. It allows researchers to refine the instrument and ensure it accurately measures the intended constructs. SMAN 3 Yogyakarta, a senior high school in Yogyakarta, Indonesia, served as the location for the pilot test. The school's diverse student population provided a valuable sample for assessing the instruments' performance. Table 8 presents the profiles of independent learning and science literacy obtained from the pilot test. These profiles provide insights into the overall levels of independent learning and science literacy among the students at SMAN 3 Yogyakarta.
The presented data sheds light on the relationship between independent learning and science literacy scores among a group of 20 respondents. While the sample size is relatively small, the results suggest a potential connection between these two skills. Independent learning, the ability to manage one's learning effectively, appears to play a role in science literacy development (Darling-Hammond et al.,

2019). A significant portion of respondents (12 out of 20) scored high in both independent learning and science literacy. This suggests that students who are independent learning and take ownership of their learning may be more likely to engage with science concepts and develop a deeper understanding of scientific principles.

However, it is important to note that not all respondents with high independent learning scores also demonstrated strong science literacy. This highlights the complex nature of learning and the influence of various factors, such as prior science knowledge, instructional approaches, and individual learning styles (Dantas & Cunha, 2020). While students' independent learning in exploring science is increasingly growing, low science literacy remains a challenge. This is due to several complex factors. First, the limited quality of learning resources (Dragoş & Mih, 2015), often restricted to free websites like Google Scholar and ScienceDirect, which lack diversity and up-to-date content, can hinder a deep understanding of scientific concepts. Second, misconceptions or misunderstandings about scientific concepts can be deeply rooted in students' minds (Hartono et al., 2023). These misconceptions are difficult to change and can hinder the understanding of more complex material. Fourth, concepts in the nervous system are often abstract and difficult to visualize. Students may struggle to connect these abstract and difficult concepts to everyday experiences (Kvello & Gericke, 2021).

The low science literacy among students is not solely caused by individual student factors, but also by systemic factors. including the limitations and shortcomings of standardized tests and ineffective teaching methods. Standardized tests like PISA are often not entirely objective in measuring students' science abilities across diverse characteristics (Bellová et al., 2018). These tests only measure specific aspects of scientific competence, thus failing to provide a comprehensive picture of students' science literacy. To improve science literacy, efforts such as curriculum revision, teacher quality enhancement, technology utilization, and collaboration with families or communities are necessary. Teaching methods that are too theoretical and do not actively involve students in scientific activities also pose obstacles (Ke et al., 2021). Teachers may lack the necessary training and expertise to effectively implement innovative teaching methods and address students' misconceptions. Curriculum adaptation should focus on conceptual understanding and critical thinking skills that support students' science literacy (Sjöström & Eilks, 2018). Government policies providing teacher training can enhance their abilities in implementing effective teaching methods to improve science literacy (DeBoer, 2000; Villanueva, 2010). Building collaborations with families and communities, or partnerships with communities, can provide real-world learning experiences.

Further research is needed to explore the intricacies of this relationship and identify specific strategies that can foster both independent learning and science literacy. By understanding how these skills interact, educators can design effective learning environments that empower students to become independent learners and proficient in science. In conclusion, the data presented in the table provides a valuable starting point for investigating the relationship between independent learning and science literacy. Future research should aim to expand the sample size, gather qualitative data, and explore the influence of other factors that may contribute to these skills. By gaining a deeper understanding of these connections, educators can create learning environments that nurture both self-directed learning and strong science literacy among students.

Conclusion

The results of this study indicated that the independent learning and science literacy scores for students on the nervous system reveals a concerning gap. While a significant portion of students (12 out of 20) demonstrate high levels of independent learning, their science literacy scores on the nervous system topic largely fall within the "Not Good" category. This disconnect suggests that even students who can learn independently may struggle with grasping specific scientific concepts. Further investigation is needed to identify potential causes for this gap, such as the teaching methods used, the complexity of the nervous system topic itself, or a lack of prior science knowledge among the students. Addressing this discrepancy will require targeted instruction that not only fosters independent learning skills but also ensures a deeper understanding of the scientific content.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

B. R. Alfi: methodology, analysis, writing original draft preparation, review and editing; **P. Paidi:** analysis, review and editing; **A. T. Pratama:** analysis, review and editing

References

Aini, K. (2021). Students' independent learning through blended learning with a flipped classroom model during the COVID-19 pandemic. *Journal of Digital Literacy, 1*(1), 42–49. https://doi.org/10.54065/jld.1.1.2021.7

Aithal, A., & Aithal, P. S. (2020). Development and validation of survey questionnaire and experimental data. *International Journal of Management, Technology, and Social Sciences (IJMTS)*, *5*(2), 233–251. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3724105

Al-Ajmy, S. S., & Al-Mutairi, M. A. (2023). The impact and future of student's independent learning. *Multi-Knowledge Electronic Comprehensive Journal For Education & Science Publications (MECSJ).*, *68*, 1–30. https://www.researchgate.net/publication/379431603_The_Impact_and_Future_of_Student's_Independent_Learning

Belawati, T., Daryono, D., Sugilar, S., & Kusmawan, U. (2023). Development of an instrument to assess independent online learning readiness of high school students in Indonesia. *Asian Association of Open Universities Journal*, *18*(1), 34–45. https://doi.org/10.1108/AAOUJ-09-2022-0139

Bellová, R., Melicherčíková, D., & Tomčík, P. (2018). Possible reasons for low scientific literacy of Slovak students in some natural science subjects. *Research in Science and Technological Education*, *36*(2), 226–242. https://doi.org/10.1080/02635143.2017.1367656

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. In *Psychological Assessment* (Vol. 7, Issue 3, pp. 309–319). https://doi.org/10.1037//1040-3590.7.3.309

Coppi, M., Fialho, I., & Cid, M. (2023). Developing a scientific literacy assessment instrument for Portuguese 3rd cycle students. *Education Sciences*, *13*(9), 941. https://doi.org/10.3390/educsci13090941

Dantas, L. A., & Cunha, A. (2020). An integrative debate on learning styles and the learning process. *Social Sciences and Humanities Open*, *2*(1), 100017. https://doi.org/10.1016/j.ssaho.2020.100017

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2019). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, 1–44. https://doi.org/10.1080/10888691.2018.1537791

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching*, *37*(6), 582–601. https://doi.org/10.1002/1098-2736(200008)37:6<582::AID-TEA5>3.0.CO;2-L

Dragoş, V., & Mih, V. (2015). Scientific literacy in school. *Procedia - Social and Behavioral Sciences*, *209*(July), 167–172. https://doi.org/10.1016/j.sbspro.2015.11.273

Dubinsky, J. M., Roehrig, G., & Varma, S. (2022). A Place for neuroscience in teacher knowledge and education. *Mind, Brain, and Education*, *16*(4), 267–276. https://doi.org/10.1111/mbe.12334

Eberle, J., & Hobrecht, J. (2021). The lonely struggle with autonomy: A case study of first-year university students' experiences during emergency online teaching. *Computers in Human Behavior*, *121*(October 2020), 106804. https://doi.org/10.1016/j.chb.2021.106804

Essen, C. B., & Akpan, G. (2018). Analysis of difficulty and point-biserial correlation indices of 2014 akwa ibom state mock multiple choice mathematics test. *International Journal of Education and Evaluation*, *4*(5), 1–11. https://ijee.io/get/IJEE/VOL. 4 NO. 5 2018/ANALYSIS OF DIFFICULTY.pdf

Faisal, S., Rusilowati, A., & Susilaningsih, E. (2023). Science literacy assessment instrument for additives and addictive substances: Development, validation, and Rasch model analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 7826–7836. https://doi.org/10.29303/jppipa.v9i10.4376

Farhat, R. H. (2021). The impact of a balanced literacy program on the gradual release of the instructor's accountability. *International Journal of Childhood Education*, *2*(4), 32–41. https://doi.org/10.33422/ijce.v2i4.127

Filgona, J., Sakiyo, J., Gwany, D. M., & Okoronka, A. U. (2020). Motivation in learning. *Asian Journal of Education and Social Studies*, 16–37. https://doi.org/10.9734/ajess/2020/v10i430273

Franzese, M., & Iuliano, A. (2018). Correlation analysis. *Encyclopedia of Bioinformatics and Computational Biology: ABC of Bioinformatics*, *1–3*, 706–721. https://doi.org/10.1016/B978-0-12-809633-8.20358-0

Hartono, A., Djulia, E., Hasruddin, H., & Jayanti, U. N. A. D. (2023). Biology students' science literacy level on genetic concepts. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 146–152. https://doi.org/10.15294/jpii.v12i1.39941

He, L., Chen, Y., Xiong, X., Zou, X., & Lai, K. (2021). Does science literacy guarantee resistance to health rumors? The moderating effect of self-efficacy of science literacy in the relationship between science literacy and rumor belief. *International Journal of Environmental Research and Public Health*, *18*(5), 2243. https://doi.org/10.3390/ijerph18052243

Hendrayana, A. S. (2014). Learning motivation, independent learning, and academic achievement of Bidikmisi scholarship students at UPBJJ UT Bandung. *Journal of Open and Distance Learning*, *15*(2). https://doi.org/10.33830/ptjj.v15i2.591.2014

Hockings, C., Thomas, L., Ottaway, J., & Jones, R. (2018). Independent learning–what we do when you're not there. *Teaching in Higher Education*, *23*(2), 145–161. https://doi.org/10.1080/13562517.2017.1332031

Horton, F. . W. (2007). *Understanding information literacy: A primer*. https://www.voced.edu.au/content/ngv%3A61828

Jurecki, K., & Wander, M. C. F. (2012). Science literacy, critical thinking, and scientific literature: Guidelines for evaluating scientific literature in the classroom. *Journal of Geoscience Education*, *60*(2), 100–105. https://doi.org/10.5408/11-221.1

Karunarathna, I., Gunasena, P., Hapuarachchi, T., Ekanayake, U., Rajapaksha, S., Gunawardana, K., Aluthge, P., Bandara, S., Jayawardana, A., Alvis, K. De, & Gunathilake1, S. (2024). The crucial role of data collection in research: Techniques, challenges, and the crucial role of data collection in research : techniques, challenges, and best practices. *Uva Clinical Research*, *June*. https://www.researchgate.net/publication/383155720_The_Crucial_Role_of_Data_Collection_in_Research_Techniques_Challenges_and_Best_Practices

Ke, L., Sadler, T. D., Zangori, L., & Friedrichsen, P. J. (2021). Developing and using multiple models to promote scientific literacy in the context of socio-scientific issues. *Science & Education*, *30*(3), 589–607. https://doi.org/10.1007/s11191-021-00206-1

Kvello, P., & Gericke, N. (2021). Identifying knowledge important to teach about the nervous system in the context of secondary biology and science education-A Delphi study. In *PLoS ONE* (Vol. 16, Issue 12 December). https://doi.org/10.1371/journal.pone.0260752

Livingstone, S. (2004). Media literacy and the challenge of new information and communication technologies. *The Communication Review*, *7*(March 2013), 86. https://doi.org/10.1080/10714420490280152

Pandiangan, P. (2023). The power of the physics independent learning model instrument in online tutorials to enhance independent learning skills and critical thinking skills. *Advances in Social Sciences Research Journal*, *10*(4), 269–287. https://doi.org/10.14738/assrj.104.14564

Pyle, S. J. (2017). *The instructional leadership role of the principal in independent schools: towards 21st century classrooms* (Vol. 4, Issue February). University of South Africa. https://uir.unisa.ac.za/bitstream/handle/10500/22726/dissertation_pyle_sj.pdf

Rahmawati, Y., Supriatna, E., & Yuliani, W. (2022). Validitas dan reliabiltas angket kemandirian belajar siswa SMP. *FOKUS (Kajian Bimbingan & Konseling Dalam Pendidikan)*, *5*(3), 254–258. https://doi.org/10.22460/fokus.v5i3.7260

Reynders, G., Lantz, J., Ruder, S. M., Stanford, C. L., & Cole, R. S. (2020). Rubrics to assess critical thinking and information processing in undergraduate STEM courses. *International Journal of STEM Education*, *7*(1). https://doi.org/10.1186/s40594-020-00208-5

Ridwan, M., & Ramdhan, F. (2021). Profile of science literacy skills of eighth-grade students on the concept of environmental pollution. *Bioed: Journal of Biology Education*, *8*(1), 34. https://doi.org/10.25157/jpb.v8i1.5993

Sharon, A. J., & Baram-Tsabari, A. (2020). Can science literacy help individuals identify misinformation in everyday life? *Science Education*, *104*(5), 873–894. https://doi.org/10.1002/sce.21581

Shrestha, N. (2021). Factor analysis as a tool for survey analysis. *American Journal of Applied Mathematics and Statistics*, *9*(1), 4–11. https://doi.org/10.12691/ajams-9-1-2

Sjöström, J., & Eilks, I. (2018). Reconsidering different visions of scientific literacy and science education based on the concept of bildung. In *Cognition, Metacognition, and Culture in STEM Education. Innovations in Science Education and Technology* (pp. 65–88). https://doi.org/10.1007/978-3-319-66659-4_4

Smith, A. B., Rush, R., Fallowfield, L. J., Velikova, G., & Sharpe, M. (2008). Rasch fit statistics and sample size considerations for polytomous data. *BMC Medical Research Methodology*, *8*(1), 33. https://doi.org/10.1186/1471-2288-8-33

Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal of Medical Education*, *2*, 53–55. https://doi.org/10.5116/ijme.4dfb.8dfd

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional development for training teachers of exceptional children*. Indiana University. https://files.eric.ed.gov/fulltext/ED090725.pdf

Valladares, L. (2021). Scientific literacy and social transformation. *Science & Education*, *30*(3), 557–587. https://doi.org/10.1007/s11191-021-00205-2

Villanueva, M. G. (2010). *Integrated teaching strategies model for improved scientific literacy in second-language learners* (Issue January) https://www.mandela.ac.za/helpingteachers/GroupProjectWebb/MARY GRACE FLORES VILLANUEVA PhD.pdf

Wadkar, S. K., Singh, K., Chakravarty, R., & Argade, S. D. (2016). Assessing the reliability of attitude scale by Cronbach's alpha. *Journal of Global Communication*, *9*(2), 113. https://doi.org/10.5958/0976-2442.2016.00019.7

Wati, M., Mahtari, S., Muthi'ah, A., Dewantara, D., & Suharno, S. (2023). The scientific literacy test Instrument on particle dynamics for high school students. *Asian Journal of Assessment in Teaching and Learning*, *13*(2), 46–56. https://doi.org/10.37134/ajatel.vol13.2.5.2023

Wege, K., Harso, A., & Wolo, D. (2022). Analysis of student learning independence during the pandemic. *Journal of Research in Instructional*, *2*(1), 87–96. https://doi.org/10.30862/jri.v2i1.34

Zadworna, M., Kossakowska, K., & Renshaw, T. L. (2023). Measuring subjective wellbeing in a school context: A polish version of the student subjective wellbeing questionnaire. *School Mental Health*, *15*(1), 231–246. https://doi.org/10.1007/s12310-022-09546-x