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Validity and Reliability of the INSPIRE: Instrument Perceptions Science Inquiry and Nature of Science

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Abstract— This research discusses about validity and reliability of teachers' perceptions of scientists, natural science (science) subjects, as well as the nature of science and scientific inquiry. The research was conducted by distributing questionnaires to science teachers in various regions for two weeks, which included 81 closed questions and 23 open questions. The results of the analysis show that the instruments used are valid and reliable, with the majority of teachers having a good understanding of the nature of science and the importance of science teaching. However, there is variation in perceptions regarding the characteristics of scientists and the effectiveness of inquiry methods. These findings highlight the need for ongoing professional development for teachers to improve the quality of science education. This research succeeded in developing and testing a valid and reliable INSPIRE instrument to measure science teachers' perceptions of scientists, science subjects, the nature of science (NOS), and the nature of scientific inquiry (NOSI). The research results show that this instrument can be used as an effective evaluation tool to understand teacher perceptions, which in turn can be a basis for designing more appropriate educational interventions.

Keywords— Teachers' perceptions; science scientists; nature of science; science inquiry; validity and reliability.
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Introduction

Teachers' perceptions of scientists and scientific inquiry play a crucial role in natural science (science) learning at the secondary school level. A deep understanding of how teachers view scientists and their inquiry science approach can influence their teaching methods and directly impact the way students understand scientific concepts. Teachers who have positive perceptions of scientists and science tend to adopt more innovative teaching approaches, including using inquiry methods that focus on scientific investigations and experiments (Havu-Nuutinen et al., 2019). Kurtzworth-Keen & Harper's (2021) research shows that teachers who view science as a collaborative and evidence-based process are more likely to implement inquiry-based learning in the classroom. Therefore, it is important to have reliable tools to evaluate these perceptions in order to provide an accurate picture of teachers' perspectives, as well as assist in formulating relevant educational policies or interventions.

Apart from perceptions of scientists and teaching methods, the importance of teachers' understanding of the Nature of Science (NOS) and the Nature of Scientific Inquiry (NOSI) cannot be ignored. NOS refers to the characteristics and values that underlie science, such as its tentative, evidence-based, and empirical nature. A good understanding of NOS helps teachers convey that science is not just a collection of facts, but a dynamic process that continues to develop as new facts are discovered (Yacoubian, 2020), besides that it can also train critical thinking skills and scientific literacy (Dewitasari & Rusmini, 2023; Takda, A. et al, 2022; Wulandari, F. et al, 2021). Meanwhile, NOSI focuses on the process of scientific inquiry—namely how science is conducted through asking questions, collecting data, and analyzing to draw evidence-based conclusions (Lederman et al., 2021). Research shows that teachers who understand the concepts of NOS and NOSI are more effective in teaching students to think critically and practice scientific methods (Mesci et al., 2020). Another research conducted by Pavez, et al (2023) said that NOSI is an important component in scientific literacy and an important educational goal in science education.

The instruments used to evaluate teachers' perceptions of scientists, NOS, and NOSI must have adequate validity and reliability so that the results can be relied on. Validity refers to the extent to which an instrument measures what it is supposed to measure, while reliability relates to the consistency of the results provided by the instrument when used repeatedly. Invalid or unreliable instruments can provide biased and misleading results, thereby hampering efforts to fully understand teacher perceptions. In this research, the INSPIRE instrument was designed to measure science teachers' perceptions of scientists, science subjects, and the nature of science and science inquiry. However, before being widely used, this instrument must go through a series of validity and reliability tests to ensure that the results are accurate and reliable.

This research aims to evaluate the validity and reliability of INSPIRE using a quantitative approach. Validity tests were

carried out to ensure that each item in this instrument truly measured the perception dimension in question, while reliability tests were carried out to assess the consistency of the answers given by respondents. The research results of Rosli et al. (2021) stated that reliability testing using Cronbach's Alpha method has been widely used in developing educational instruments, which provides a strong indication of the internal consistency of the instrument.

Research on the validity and reliability of this instrument is very important because the results of this instrument can be used as a basis for decision-making in the educational realm, especially in the context of teacher professional development. With a valid and reliable instrument, teachers' perceptions regarding scientists, NOS, and NOSI can be more precisely known, which can then be directed toward improving the quality of science teaching in schools. It is hoped that the results of this research can contribute to the development of perception measurement instruments in the field of science education and open up opportunities for more effective interventions in improving perceptions and practices of science teaching in the field.

Method

This research uses a quantitative approach with survey methods to evaluate the validity and reliability of INSPIRE. This instrument is designed to measure science teachers' perceptions of scientists, science subjects, the nature of science (NOS), and the nature of scientific inquiry (NOSI). The population of this study was junior high school science teachers spread across several regions in Indonesia, using random sampling techniques to obtain a representative sample. Respondents expected to participate range from 50-100 teachers, which is the minimum standard for testing the validity and reliability of instruments. After distributing the instrument, 61 respondents participated.

The instrument used consists of statements that are measured using a five-point Likert scale, ranging from "Strongly Agree" to "Strongly Disagree". Validity testing is carried out in two stages, namely content validity and construct validity. Content validity was tested by science education experts to assess the suitability of each item to the concept being measured, while construct validity was tested using Pearson Product Moment with a significance level of 0.05 or 5% to look for correlations between each question and the total score. The reliability of the instrument was tested using Cronbach's Alpha coefficient, with a minimum value of 0.7 as an indicator of good internal consistency. In addition, reliability was also tested for each subscale to ensure consistency in each category.

The sampling technique used Purposive Sampling, where respondents were junior high school science teachers spread throughout Indonesia, starting from the West Nusa Tenggara region (Mataram, Central Lombok, West Lombok, East Lombok, Sumbawa, Bima, and Dompu), Bali, Aceh Province, to West Java (Sukabumi). Respondents were selected based on the criteria of being junior high school science teachers and from their willingness to fill out the online questionnaire that was distributed. Respondents came from 47 different schools, with different ages, teaching experiences, genders, and last education.

Data collection was carried out through an online survey using Google Forms, where respondents were asked to fill out a questionnaire voluntarily. The online survey was carried out by sending a link to the questionnaire via email, while the offline survey was given physically to teachers at each school. After the data was collected, analysis was carried out using descriptive statistics to describe the characteristics of the respondents. The validity test was carried out using the Pearson Product Moment test, while the reliability test was carried out using Cronbach's Alpha coefficient to measure the internal consistency of the instrument. The results of this validity and reliability test will provide empirical evidence regarding the suitability of the INSPIRE instrument as a valid and reliable measuring tool in evaluating teachers' perceptions of scientists and science inquiry.

Result and Discussion

In the context of natural science education, teachers' understanding of scientists, science subjects, and the nature of science and scientific inquiry are crucial aspects that influence the quality of teaching. This article explains the various indicators identified through the teacher perception instrument, which include the characteristics of scientists, understanding of basic science concepts, and important skills in the scientific inquiry process. By conducting questionnaire trials with science teachers in various regions, this research aims to evaluate their views and knowledge, as well as provide deeper insight into the role of teachers in shaping students' understanding of science.

The instrument for teachers' perceptions of science scientists, science subjects, the nature of science, and the nature of science inquiry, has several indicators. Indicators of science scientists include mental characteristics such as perfectionism, diligence and open-mindedness, as well as various religious backgrounds. Physically, scientists can have a variety of appearances, including hairstyles and use of lab coats. Sources of information about scientists can be found in biographies, science journals, and personal experiences, which inspire the desire to become a scientist. Indicators of scientific understanding include mastery of facts, concepts, principles, laws, theories, and models needed to explain and predict phenomena and apply them in new situations. In addition, science process skills involve a series of steps such as observing, questioning, planning an investigation, processing, analyzing data, evaluating, and communicating results. These skills are important for developing deep understanding and scientific abilities in practice. Then, indicators of the nature of science include tentative scientific knowledge, where theories and hypotheses are continuously tested and validated through scientific methods and objective observations. Apart from that, science also requires imagination and recognizes subjectivity in the research process, which is important for understanding and explaining natural phenomena. Next are indicators of the nature of inquiry science, where indicators of the nature of inquiry science include the ability to recognize and develop questions that can be answered through natural science investigations, including experiments. Students are expected to be able to plan investigations to test predictions and hypotheses, conduct qualitative and quantitative experiments, and write lab reports. Additionally, they must collect and analyze data to identify trends and relationships, as well as use relevant models to solve scientific questions.

The samples taken came from various regions, and obtained 61 respondents from 47 schools spread across Indonesia. The

distribution of samples was uneven due to the limitations of researchers in getting respondents who were willing to voluntarily fill out the instrument. The sample also uses certain criteria, namely respondents who are junior high school science teachers. Although using Google Form so that the scope of respondents is wider, the distribution is not even. Geographical sample limitations have important implications for the generalizability of research results. Generalizability refers to the extent to which findings from a sample can be applied or generalized to a broader population. If the sample is drawn from only a specific geographic area, then the results may only reflect characteristics, social, cultural, economic, or educational conditions specific to that area. Thus, the findings obtained may be less representative of the broader or different regional population, reducing the ability to generalize the results of the study to more general or geographically diverse contexts.

In addition, geographical limitations can also cause bias in research results due to the lack of variation in the sample. For example, if the research is only conducted in an urban area, the results may not be relevant or less accurate if applied to rural areas that have different conditions and experiences. Therefore, it is important for researchers to acknowledge these limitations in the research report and limit conclusions to the appropriate geographic context. As a mitigation step, researchers can recommend further research with more geographically diverse samples to increase external validity and expand the scope of generalization of the results in the future. Thus, readers and users of the research results can understand the limitations of the application of the findings properly.

The limitation of samples that only come from certain geographic areas can limit the ability to generalize research results to a wider population because the characteristics and conditions in those areas may not be representative of other areas, thus creating bias and reducing external validity. Therefore, it is important to expand the scope of respondents by involving various regions and diverse backgrounds so that the findings are more representative and can be applied more generally, for example by using geographically stratified sampling methods or online surveys to reach respondents from various locations.

In this study, the instrument used was developed from several indicators related to scientists, science subjects, NOS and NOSI that have previously been discussed in related studies, such as Bozdoğan et al. (2018) on high school students' perceptions of scientists, Chen (2006) on an instrument to assess views on NOS, and Pérez & Díaz-Moreno (2022) on the development of NOSI through immersion and reflection. Indicators from previous studies were developed to be broader, for example, indicators of physical characteristics of scientists were developed to be more specific such as glasses, hairstyle, mustache or beard, neatness, and height. In addition, this study specifically targets junior high school science teachers as the research sample. While previous studies focused on students from various levels of education. This focus allows the study to gain a deeper understanding of the perceptions of junior high school science teachers, who have an important role in shaping students' understanding of science. Previous studies provide a broader and more comprehensive picture of the reliability and validity of scientific instruments in general, with various examples and approaches that can be used as references for the development of other instruments. Previous research was more of a general study and a broader study of the reliability and validity of instruments, including the TOSRA (Test of Science Related Attitudes), which is an established instrument and is widely used in science education research. However, its nature is more theoretical and general, so it is less in-depth on one specific instrument such as INSPIRE in this study. This is what makes this instrument superior and new. Research related to the INSPIRE instrument focuses on the validity and reliability of the INSPIRE instrument measuring perceptions of science, inquiry, and the nature of science, with detailed explanations of the instrument testing methodology, statistical analyses such as Cronbach's Alpha, and interpretation of results specific to the instrument.

The INSPIRE instrument used in this study combines several important aspects of science perception, namely perceptions of scientists, science subjects, NOS, and NOSI. Many previous studies have examined these aspects, but none have combined these four aspects into one single instrument. This instrument may be more comprehensive than the instruments used in previous studies that only focused on one or two aspects. In addition to using a Likert scale, the INSPIRE instrument also includes open-ended questions. This allows teachers to provide more in-depth and detailed answers about their perceptions. Qualitative data from these open-ended questions can provide richer and more nuanced insights than quantitative data alone. This study was conducted in the context of the implementation of the Merdeka Curriculum in Indonesia. Previous studies may have been conducted in different curriculum contexts. Therefore, this study can provide relevant information on how junior high school science teachers understand and implement science concepts in this new curriculum.

This study has the potential to provide new findings or perspectives, namely the profile of junior high school science teachers' perceptions of scientists, science subjects, NOS, and NOSI in Indonesia; the relationship between teacher perceptions and teacher characteristics (e.g., age, education, teaching experience, certification); the influence of the Independent Curriculum on teacher perceptions of science and science learning; and identification of areas of strength and weakness in teacher perceptions of science, which can be used to develop more effective teacher training programs. This study has the potential to make a significant contribution to understanding junior high school science teachers' perceptions of science in Indonesia. With a focus on teachers, the use of comprehensive instruments, the integration of open-ended questions, the context of the Independent Curriculum, and attention to NOSI, this study can provide valuable new findings and perspectives for the development of science education in Indonesia.

The trial of the instrument for teachers' perceptions of science scientists, science subjects, the nature of science, and the nature of science inquiry was carried out for 2 weeks by distributing questionnaires online to science teachers in various regions, and offline to science teachers at SMPN 6 Mataram. The questionnaire distributed online contained 81 closed questions and received 61 respondents. Open questions totaling 23 items were tested using expert validity. Testing of the questionnaire instrument included testing the validity and reliability of 81 closed statements, where the research data was processed using SPSS. The validity test is carried out to determine whether the instrument used is valid or not, while the reliability test is carried out to determine the level of confidence in the instrument.

Validity Test

Validity testing is a way to assess the extent of the validity of an instrument. The instrument validation process was carried out to evaluate the suitability of the tool designed for the research objectives. The results of the validity test are presented in Table 1.

Table 1: Instrument validity calculated using SPSS

Cases	N	%
Valid	61	100,0
Excluded	0	0,0
Total	61	100,0

Reliability Test

Reliability tests were carried out to assess the extent of confidence in the instrument. In other words, a reliable test is a test that, when applied repeatedly to the same object, produces consistent or similar data. The results of the reliability test are presented in Table 2.

Table 2: Instrument reliability calculated using SPSS

Cronbach's Alpha	N of Items
,885	81

Tables 1 and 2 show that the results of testing the instrument produced 81 valid and reliable statements, from a total of 61 respondents' answers. This instrument is declared valid because $r_{count} > r_{table}$, where r_{table} for df=59 and a significance level of 0.05 is 0.2521. The results of calculating the validity of the instrument using product moment correlation produce $r_{count} > 0.2521$ for each closed question item. Reliability is in the very high category because the Cronbach Alpha coefficient on this instrument is 0.885. So that this instrument can be declared suitable for use to research science teachers' perceptions of science scientists, science subjects, the nature of science, and the nature of science inquiry.

Validity of Junior High School Science Teachers' Perceptions of Scientists

The validity of the instrument regarding junior high school science teachers' perceptions of science scientists shows that each statement item that has been tested is proven to be valid so the instrument is said to be suitable for testing these perceptions. This can be seen in Table 3 below.

Table 3. Validity of Junior High School Science Teachers' Perceptions of Scientists

Statement Number	r_{count}	Sig. (2-tailed)	Validity
P1	1	0.0000	Valid
P2	0.2816	0.0206	Valid
P3	0.2750	0.0316	Valid
P4	0.2606	0.0344	Valid
P5	0.2641	0.0357	Valid
P6	0.2827	0.0198	Valid
P7	0.4020	0.0013	Valid
P8	0.2796	0.0250	Valid
P9	0.2755	0.0261	Valid
P10	0.3216	0.0004	Valid
P11	0.3570	0.0048	Valid
P12	0.2700	0.0270	Valid
P13	0.3751	0.0003	Valid
P14	0.3045	0.0009	Valid
P15	0.2680	0.0444	Valid
P16	0.2700	0.0270	Valid
P17	0.2823	0.0179	Valid
P18	0.2617	0.0237	Valid
P19	0.2687	0.0258	Valid
P20	0.2859	0.0106	Valid

Analysis of the validity of junior high school science teachers' perceptions of scientists shows that all statement items from P1 to P20 have a Pearson Correlation value (r_{count}) that is greater than the r_{table} (0.2521) and a significance value (Sig. 2-tailed) that is less than 0.05. This shows that science teachers' perceptions of scientists are valid. For example, P7 with a r_{count} of 0.4020, and P10 with a r_{count} of 0.3216, both show a significant positive correlation, reflecting that science teachers have a strong view of the importance of the role of scientists in education. This validity is proof that the instrument used can be relied upon to measure the desired perception.

Validity of Junior High School Science Teachers' Perceptions of Science Subjects

The validity of the instrument regarding junior high school science teachers' perceptions of science subjects shows that each

statement item that has been tested is proven to be valid so the instrument is said to be suitable for testing these perceptions. This can be seen in Table 4 below.

Table 4. Validity of Junior High School Science Teachers' Perceptions of Science Subjects

Statement Number	r_{count}	Sig. (2-tailed)	Validity
P21	0.2901	0.0002	Valid
P22	0.2707	0.0062	Valid
P23	0.2610	0.0223	Valid
P24	0.2890	0.0214	Valid
P25	0.2780	0.0054	Valid
P26	0.2540	0.0020	Valid
P27	0.3300	0.0007	Valid
P28	0.2970	0.0021	Valid
P29	0.3010	0.0040	Valid
P30	0.2650	0.0196	Valid
P31	0.2622	0.0350	Valid
P32	0.2655	0.0280	Valid
P33	0.3120	0.0045	Valid
P34	0.3040	0.0010	Valid
P35	0.3290	0.0038	Valid
P36	0.2980	0.0120	Valid
P37	0.3500	0.0009	Valid
P38	0.2810	0.0141	Valid
P39	0.3940	0.0000	Valid
P40	0.2940	0.0115	Valid

In the validity analysis of junior high school science teachers' perceptions of science subjects, the table shows that all statement items from P21 to P40 also meet the validity criteria, with a r_{count} that is greater than the r_{table} and a significance of less than 0.05. For example, P31 with a r_{count} of 0.2622 and P39 with a r_{count} of 0.3940 show a significant positive relationship, which indicates that teachers consider science subjects to have strong relevance in learning. These results confirm that the instrument used to measure teachers' perceptions of science subjects is valid and can be used for further development.

Validity of Junior High School Science Teachers' Perceptions Nature of Science (NOS)

The validity of the instrument regarding junior high school science teachers' perceptions nature of science shows that each statement item that has been tested is proven to be valid so the instrument is said to be suitable for testing these perceptions. This can be seen in Table 5 below.

Table 5. Validity of Junior High School Science Teachers' Perceptions of NOS

Statement Number	r_{count}	Sig. (2-tailed)	Validity
P41	0.2618	0.0310	Valid
P42	0.2565	0.0456	Valid
P43	0.2890	0.0215	Valid
P44	0.2912	0.0135	Valid
P45	0.2579	0.0345	Valid
P46	0.3078	0.0022	Valid
P47	0.3040	0.0025	Valid
P48	0.2817	0.0103	Valid
P49	0.2658	0.0345	Valid
P50	0.2801	0.0223	Valid
P51	0.2838	0.0204	Valid
P52	0.2694	0.0389	Valid
P53	0.2940	0.0214	Valid
P54	0.3184	0.0037	Valid
P55	0.2982	0.0152	Valid
P56	0.2850	0.0210	Valid
P57	0.2694	0.0389	Valid
P58	0.2594	0.0445	Valid
P59	0.2798	0.0354	Valid
P60	0.2612	0.0397	Valid

The validity of junior high school science teachers' perceptions of the Nature of Science (NOS) can be seen from all statement items P41 to P60 which have a calculated r greater than 0.2521 and significance below 0.05. For example, P43 with a calculated r of 0.2890 shows that there is a significant relationship, indicating that science teachers have a good understanding of the NOS

concept and consider it important in teaching. The validity of this instrument shows that teachers' perceptions of NOS can be relied upon to describe their attitudes toward teaching broader scientific concepts.

Validity of Junior High School Science Teachers' Perceptions of Nature of Scientific Inquiry (NOSI)

The validity of the instrument regarding junior high school science teachers' perceptions nature of scientific inquiry shows that each statement item that has been tested is proven to be valid so the instrument is said to be suitable for testing these perceptions. This can be seen in Table 6 below.

Table 6. Validity of Junior High School Science Teachers' Perceptions of NOSI

Statement Number	r_{count}	Sig. (2-tailed)	Validity
P61	0.3101	0.0002	Valid
P62	0.2923	0.0105	Valid
P63	0.2658	0.0354	Valid
P64	0.2583	0.0464	Valid
P65	0.2973	0.0156	Valid
P66	0.2764	0.0248	Valid
P67	0.2883	0.0203	Valid
P68	0.2572	0.0468	Valid
P69	0.3710	0.0089	Valid
P70	0.2903	0.0114	Valid
P71	0.2756	0.0281	Valid
P72	0.2981	0.0128	Valid
P73	0.2599	0.0452	Valid
P74	0.2561	0.0402	Valid
P75	0.2990	0.0131	Valid
P76	0.2563	0.0456	Valid
P77	0.2914	0.0165	Valid
P78	0.2829	0.0246	Valid
P79	0.2654	0.0324	Valid
P80	0.2800	0.0266	Valid
P81	0.2625	0.0415	Valid

Validity analysis for junior high school science teachers' perceptions of the Nature of Scientific Inquiry (NOSI) indicates that all statement items from P61 to P81 meet the validity criteria. For example, P61 with a calculated r of 0.3101 and P69 with a calculated r of 0.3710 show a significant positive relationship, which reflects that science teachers understand and appreciate the scientific approach to learning. This validity indicates that the instrument used is effective in measuring teachers' perceptions of NOSI so that it can be a basis for improving teaching methods and developing relevant curricula.

A Cronbach's Alpha score of 0.885 indicates that your instrument has good internal reliability and is consistent in measuring the intended construct. This value falls into the "good" category by psychometric standards, which typically consider values between 0.8 and 0.9 to indicate strong consistency between items. When compared to similar studies in education and social sciences, this score is very competitive and in line with the results of studies that have developed science perception and inquiry instruments, such as the TOSRA instrument (Fraser, 1981) and the Studies of the Science and Technology Course Scientific Attitude Scale (YAŞAR et al., 2009), which generally report reliability values between 0.82 and 0.89.

Although the Cronbach's Alpha score of 0.885 is good, there are several aspects that can be considered to improve the quality of the instrument. Check the correlation of each item with the total score of the instrument. Items with low correlation (<0.3) can be candidates for revision or deletion because they may not be consistent with the construct being measured. Conduct exploratory or confirmatory factor analysis to ensure that the items are clustered according to the expected dimensions. Items that do not load well on the main factors can be revised. Sometimes, instruments that are too long can decrease reliability due to respondent fatigue. Shortening the instrument by selecting the most representative items can increase reliability. Make sure all items are easy to understand and unambiguous. Confusing items can lead to inconsistent answers. In addition to internal reliability, retesting at different times can provide an overview of the temporal reliability of the instrument. With these steps, the instrument can be more valid and reliable in measuring science perceptions and inquiry.

Based on the results of the analysis that has been carried out, it can be concluded that the INSPIRE instrument used to measure teachers' perceptions of scientists, science subjects, the nature of science (NOS), and the nature of scientific inquiry (NOSI) has been proven to be valid and reliable. The results of the validity and reliability tests show that this instrument is able to measure the dimensions of perception in question with high consistency. These findings indicate that science teachers at the junior high school level have a good understanding of NOS and NOSI, although there are variations in their perceptions of the characteristics of scientists and the effectiveness of inquiry methods. This emphasizes the importance of continuous professional development for teachers to improve the quality of science learning, as well as the need for accurate and reliable instruments to evaluate teacher perceptions in the context of science education.

Conclusion

This research succeeded in developing and testing a valid and reliable INSPIRE instrument to measure science teachers' perceptions of scientists, science subjects, the nature of science (NOS), and the nature of scientific inquiry (NOSI). The research results show that this instrument can be used as an effective evaluation tool to understand teacher perceptions, which in turn can be a basis for designing more appropriate educational interventions. However, this research still has limitations, especially in terms of the relatively moderate number of respondents and limited geographic coverage. Therefore, it is recommended that further research be carried out involving more respondents from various regions to strengthen the generalization of the results. Apart from that, there is a need for training and workshops for teachers to increase their understanding of NOS and NOSI, as well as the application of inquiry methods in science learning. In this way, it is hoped that the quality of science education in Indonesia can continue to be improved. It is hoped that in the future, this instrument can be useful as an evaluation material for assessing teachers' perceptions of science scientists, science subjects, NOS, and NOSI.

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