JPPIPA 9(Special Issue) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Assessment: The Quality of Instrument to Measure Student's Scientific Attitude (SSA) based on Content Validity and Empirical Testing

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Received: September 15, 2023
Revised: November 17, 2023
Accepted: December 25, 2023
Published: December 31, 2023

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DOI: 10.29303/jppipa.v9iSpecialIssue.6816

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Abstract: This research aims to determine the questionnaire quality based on: (1) content validity, and (2) empirical testing. The research was research and development using the 4-D model (defining, designing, developing, and disseminating stage). The instrument validation was conducted by an instrument expert, two physics teachers, and five peer reviewers. The subject of empirical testing was 206 students of class XII IPA SMAN 6 Yogyakarta in the 2019/2020 school year. The research instrument was a questionnaire of student's scientific attitude (SSA) that consists of 20 statement items. The data were analyzed using the raw scale for content validity of the SSA questionnaire, and Product Moment Pearson for empirical testing validation using SPSS 16, and Cronbach's Alpha value to determine the reliability. The results show that (1) all items of the SSA questionnaire meet content validity with raw scale score between 3.75 and 4, which means on excellent category; (2) the SSA questionnaire meet empirical validity with Product Moment Pearson r between 0.186 and 0.595; all $r > r_{table}$: 0.138 (n=206; $\alpha = 0.05$), and meet reliability with Cronbach's Alpha value between 0.724 and 0.756; all value > 0.60; which means the SSA questionnaire are feasible to use based on empirical testing.

Keywords: Assessment; Physics; Questionnaire; Scientific attitude.

Introduction

Physics is one of the topics that play a crucial role in human life. This is because physics is very important to understand the world (Baran, 2016; Tural, 2013). Many tools for human needs are developed based on the concepts of physics (Kira & Nchunga, 2015). Physics learns about events or a natural phenomenon that are complexly interconnected (Zitzewitz, 2011; Halliday & Resnick, 2015). Physics is used in everyday life, for example in crime-solving cases, the health sector, up in the kitchen (Holubova, 2013). Physics is the science used to search for answers to a natural phenomenon in daily life (Saleh, 2014). In addition to a fairly complex mathematical rectification, physics also requires students to be able to analyze the physical phenomena to solve the physical problems facing them.

The concept of learning with a scientific approach focuses on balancing all competence (Astuti et al., 2016). This means that instead of knowledge and skills, attitude is also a matter of concern. Scientific attitude is an attitude that must be owned by someone who is studying natural science (Sutopo et al., 2016).

Through learning physics, the students are also expected to be scientific. Scientific attitude is very important in learning science, including physics (Putra et al., 2018). Scientific attitude can help students to feel the science and understand the world through acting like a scientist (Rohmani et al., 2015; Eralita et al., 2015). Scientific attitude is the most important outcome of science teaching and enables us to think rationally (Raja, 2016). Learning derived from experience, education, and problem identification is applied to scientific attitudes (Hasbiyati et al., 2022). The goal of science learning is for

How to Cite:
Kurnianto, A.A., & Mundilarto, M. (2023). Assessment: The Quality of Instrument to Measure Student's Scientific Attitude (SSA) based on Content Validity and Empirical Testing. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 732–739. https://doi.org/10.29303/jppipa.v9iSpecialIssue.6816

students to acquire experience through organizing and carrying out scientific performance activities to develop scientific attitudes and raise awareness for the preservation and upkeep of the environment and natural resources (Hendracipta, 2016). As such, scientific attitudes are qualities that students learning physics must possess. Since students must be able to learn through a variety of scientific job situations, scientific attitudes are crucial to their scientific education.

Scientific attitude is people's behavior when solving a problem through systematic scientific steps (Kusherawati et al., 2020; Ardiansyah & Arda, 2020). Scientific attitude in learning science is often associated with attitudes toward science (Guritno et al., 2015) but it is different. Scientific attitude has a different meaning to the attitude towards science and the ability to carry out scientific procedures (Ekawati, 2017). A capacity to communicate everything about the environment objectively based on one's understanding is known as a scientific attitude (Revati & Meera, 2017). Individuals with a scientific mindset will be inclined to undertake experiments, methodical in their approach, and receptive to science (Nursakinah & Suyanta, 2023).

Scientific attitude is a disposition of thinking that becomes a trend of research which is integrated into a high level of thinking skills that determines the quality of students (Hunaepi, 2017). Someone with a good scientific attitude will not be affected by superstition, unverified assumptions, or popular opinions that are not based on empirical data (Olatoye & Aderogba, 2012). Being scientific tends to someone having some attitude like curiosity, rationality, the willingness to delay an opinion or decision, open-mindedness, critical-mindedness, objectivity, honesty, and humility (Olasehinde & Olatoye, 2014). The aspects of scientific attitude include curiosity, respect for facts or evidence, willingness to change views, and critical thinking (Ananda et al., 2022). Components of scientific attitudes are open-minded attitudes, thinking critically, attention to facts or evidence, the willingness to change their minds, suspension of decisions, objectivity, and desire to ask (Srivastava, 2014; Ahuja, 2017). A shared set of attitudes in scientific practice is closely linked to the techniques and abilities employed by scientists.

Scientific attitudes are important in a scientific investigation and must be assessed by a qualified instrument. An assessment can control the quality of the education curriculum (Isnaeni & Kumaidi, 2015). A good assessment can foster problem-solving skills (Kinay & Bagceci, 2016). Assessment is an activity to measure the achievement of students by collecting and processing information (Fathayati et al., 2022). The assessment is needed to determine how successful a process of learning has been by the teachers and students (Kurnianto & Mundilarto, 2021). Assessment can be used to make decisions because it is an information-gathering process on student outcomes and learning outcomes. The presence of scientific attitude assessment instruments becomes part need to be prepared, to monitor the progress of the scientific attitude of students.

Based on the above background, this study was focused on developing of student's scientific attitude (SSA) assessment with nine indicators of scientific attitude.

Method

This research is development research. The research method used was a combination of R&D and 4D models. The R&D model consists of research and development (Borg et al., 2007). The development stage of this model uses the 4D model. The 4-D model consists of defining, designing, developing, and dissemination. The combination of these two models resulted in a development stage consisting of research, defining, designing, developing, and dissemination (Thiagarajan et al., 1974). The diagram combination of both models can be seen in Figure 1.

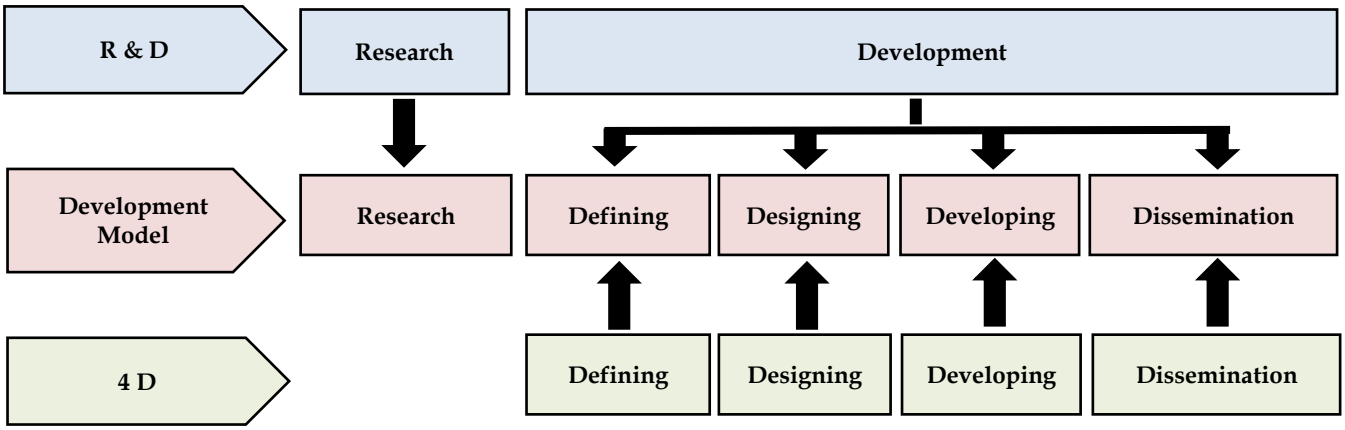

Figure 1. Diagram of combination between R & D and 4-D

The research stage consists of a literature review and an empirical study. The define stage contains four steps, namely preliminary analysis, analysis of student, analysis of concept, and goal specification of learning. In the design stage, there are determined SSA indicators and the items of the questionnaire. In the development stage, there are five steps, namely prototype, content validity (using raw scale analysis), empirical testing, empirical validity (using Product Moment Pearson analysis), and reliability (using Cronbach Alpha value). The dissemination stage consists of counseling in the subject matter teacher meeting and journal publication.

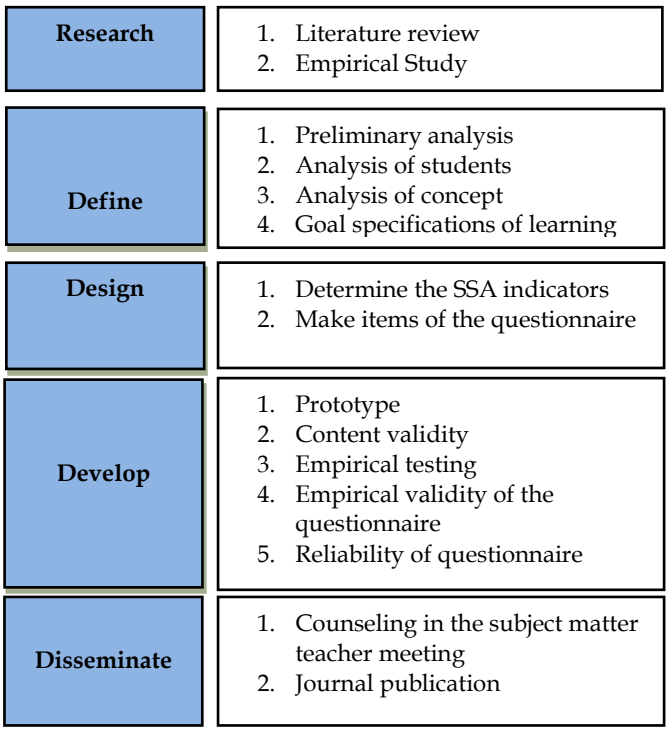

Figure 2. Diagram of procedure development model

The subject used in this research is 12th grade of science students of senior high school in Yogyakarta. The sample is determined by purposive sampling which consists of 206 students of SMAN 6 Yogyakarta in the 2019/2020 school year. The sample distribution is shown in Table 1.

Table 1. Sample Distribution

Class	Students	Class	Students
1st 12th Science	26	5th 12th Science	20
2nd 12th Science	29	6th 12th Science	21
3th 12th Science	30	7th 12th Science	26
4th 12th Science	27	8th 12th Science	27

The categories of validation criteria for the SSA instrument are shown in Table 2. The score of validity was a 1-4 scale.

Table 2. Validation Criteria of SSA Instrument

Total Average	Category
$\bar{X} > 3.4$	Excellent
$2.8 > \bar{X} \geq 3.4$	Good
$2.2 > \bar{X} \geq 2.8$	Fairly
$1.6 > \bar{X} \geq 2.2$	Less
$\bar{X} \leq 1.6$	Poor

The research instrument used is a questionnaire of scientific attitude that contains 20 items of statement. The instrument was developed based on the indicators of SSA. The indicators used and instrument grids of SSA are shown in Table 3.

Table 3. Indicator of SSA

Topic	Indicator	Indicator Description
Scientific Attitude	Curiosity	Students have a desire to know something
	Rationality	Students accustomed to looking for scientific reason and do not believe in superstitious
	Willingness to suspend judgment	This is related to a strong desire to investigate before deciding by seeking the relevant facts
	Open-mindedness	Students have the willingness to change their minds when he/she find other facts and try to see something from a wider perspective
	Critical-mindedness	Students with this characteristic usually ask for evidence and argument that supports the other statement, which in this case refers to the reason behind the statement maker
	Objectivity	Students with this attitude tend to appreciate the fact and try to respond based on it
	Honesty	The awareness to write and/or report the real data obtained, and do their task on their own
	Humility	Realized that he/she cannot be separated from error. There might be some better ideas, and anyone else could have to invited to the discussion to achieve observation and the right conclusion.
	Responsibility	Students tend to actively do their tasks and are adherent to the task given to them

Result and Discussion

Items in the questionnaire of SSA were validated by instrument experts, practitioners, peers amount 8 raters. The results of data analysis for the SSA questionnaire using the raw scale are shown in Table 4.

Table 4. The Results of content validity for the SSA questionnaire

Aspect		Average	Category
Instructional		4	Excellent
Curiosity	Item 1	4	Excellent
	Item 2	4	Excellent
	Item 3	4	Excellent
	Item 4	4	Excellent
Rationality	Item 5	4	Excellent
	Item 6	4	Excellent
Willingness to suspend judgment	Item 7	4	Excellent
Open-mindedness	Item 8	4	Excellent
	Item 9	4	Excellent
Critical-mindedness	Item 10	3.87	Excellent
	Item 11	4	Excellent
	Item 12	4	Excellent
Objectivity	Item 13	4	Excellent
	Item 14	4	Excellent
Honesty	Item 15	3.87	Excellent
	Item 16	4	Excellent
Humility	Item 17	4	Excellent
	Item 18	3.75	Excellent
Responsibility	Item 19	4	Excellent
	Item 20	4	Excellent
Grammar		4	Excellent
		4	Excellent
		4	Excellent
		3.87	Excellent
Total Average		3.97	Excellent

Based on Table 4, known that the SSA questionnaire includes excellent categories which score 3.97. The non-test instrument of SSA in the form of the questionnaire, based on validation by 8 raters, is known to be suitable for use and includes excellent categories. This is known based on analysis using the raw scale. In the next stage, empirical testing was conducted on 206 students at SMAN 6 Yogyakarta in the 2019/2020 school year to determine the empirical validity and reliability. The grids of the SSA questionnaire are shown in Table 5.

Table 5. Grids of SSA questionnaire

The indicators of SSA	Description	Item
Curiosity	Students pay attention to explanations or demonstrations from the teachers	1
	Students ask about the physical phenomenon presented	2
	The student answered the teacher's question enthusiastically	3
Rationality	Students are looking for reasonable causes related to a physical phenomenon	4
	Students do not expose the reasons affected by imagination or fairy tales related to physical phenomena	5
Willingness to suspend judgment	Students investigate the relevant facts carefully	6
	Students are patient in concluding and finding strong evidence	7
Open-mindedness	Students appreciate the opinions of others.	8
	Students look at the physics phenomenon not just from one point of view	9
Critical-mindedness	Students are asking for evidence that supports a statement	10
	Students ask for reasons for decision-making	11
	Students ask for any new change or discovery	12
Objectivity	Students see a physics phenomenon based on fact	13
	The students don't speculate based on their feelings or desires related to a physical phenomenon	14
Honesty	Students are trying to do individual tasks on their own.	15

The indicators of SSA	Description	Item
	The students relayed the results of observations related to the physics phenomenon as it is	16
Humility	Students are willing to accept feedback	17
	Students are willing to accept if their arguments are wrong	18
Responsibility	Students work with enthusiasm	19
	Students gather tasks on time	20

The empirical validity of the SSA questionnaire was analyzed by Product Moment Pearson using SPSS 16. The decision-making of empirical validity is based on a comparison between the r_{count} and r_{table} score. Figure 3 and Table 6 show that each statement items meet $r_{count} > r_{table}$: 0,138 (n = 206; α = 0,05). That means all of the statement items in the SSA questionnaire, based on empirical testing, are valid to use.

Correlations

		Item_1	Item_2	Item_3	Item_4	Item_5	Item_6	Item_7	Item_8	Item_9
Item_20	N	206	206	206	206	206	206	206	206	206
Skor_Total	Pearson Correlation	.447**	.529**	.458**	.489**	.353**	.571**	.461**	.274**	.390**
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	.000
	N	206	206	206	206	206	206	206	206	206

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

		Item_10	Item_11	Item_12	Item_13	Item_14	Item_15	Item_16	Item_17	Item_18
Item_20	N	206	206	206	206	206	206	206	206	206
Skor_Total	Pearson Correlation	.365**	.186**	.217**	.462**	.210**	.484**	.427**	.391**	.374**
	Sig. (2-tailed)	.000	.007	.002	.000	.002	.000	.000	.000	.000
	N	206	206	206	206	206	206	206	206	206

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations

		Item_19	Item_20	Skor_Total
Item_20	N	206	206	206
Skor_Total	Pearson Correlation	.595**	.594**	1
	Sig. (2-tailed)	.000	.000	
	N	206	206	206

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 3. r_{count} Product Moment Pearson using SPSS 16.

Table 6. Category of each item statement of the SSA questionnaire

Item	r_{count}	Category	Item	r_{count}	Category
1	0.447	Valid	11	0.186	Valid
2	0.529	Valid	12	0.217	Valid
3	0.458	Valid	13	0.462	Valid
4	0.489	Valid	14	0.210	Valid
5	0.353	Valid	15	0.484	Valid
6	0.571	Valid	16	0.427	Valid
7	0.461	Valid	17	0.391	Valid
8	0.274	Valid	18	0.374	Valid
9	0.390	Valid	19	0.595	Valid
10	0.365	Valid	20	0.594	Valid

The SSA questionnaire meets empirical validity with Product Moment Pearson r between 0.186 and 0.595. The total average of r_{count} is 0.413 which means the SSA questionnaire is valid to use.

SSA questionnaire reliability was analyzed by Alpha Cronbach's, in condition if the Cronbach's Alpha value > 0,60, it means the questionnaire is reliable. Otherwise, if the Cronbach's Alpha value < 0,60, then the questionnaire is not reliable or inconsistent.

Reliability Statistics

Cronbach's Alpha	N of Items
.750	20

Figure 4. Cronbach's Alpha value

Figure 4 shows that Cronbach's Alpha value meets 0,75; which is bigger than 0,60. Figure 5 shows the reliability of the item statement. Cronbach's Alpha's biggest value is owned by item 14 with a value meet 0.756; while the smallest one is owned by item 19 with a value meet 0.724. Based on Figure 8 and Figure 9, known that all of the statement items in the SSA questionnaire were reliable or consistent.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Item_1	57.19	34.057	.369	.738
Item_2	57.83	32.916	.442	.731
Item_3	57.67	33.186	.353	.737
Item_4	57.53	32.933	.388	.734
Item_5	57.28	33.811	.220	.749
Item_6	57.74	32.270	.482	.727
Item_7	57.45	33.215	.358	.737
Item_8	56.90	35.473	.204	.747
Item_9	57.27	34.031	.290	.742
Item_10	57.82	34.041	.253	.745
Item_11	58.25	35.738	.084	.755
Item_12	58.12	35.430	.106	.755
Item_13	57.25	33.526	.371	.736
Item_14	57.76	35.443	.093	.756
Item_15	58.16	32.834	.377	.735
Item_16	57.53	33.440	.318	.740
Item_17	57.71	33.522	.266	.744
Item_18	57.18	34.129	.271	.743
Item_19	57.93	31.449	.495	.724
Item_20	57.79	30.715	.475	.725

Figure 5. Reliability of item statement using SPSS 16.

Some researchers only used four indicators, namely communication skills, curiosity, responsibility, and thoroughness (Israfiddin et al., 2016; Hikmawati et al., 2021). Another researcher has examined the indicators of scientific attitude were accuracy, honesty, responsibility, and cooperation (Hasbiyati et al., 2022). This research focuses on developing an assessment of scientific attitude with nine indicators, namely (1) curiosity, (2) rationality, (3) willingness to suspend judgment, (4) open-mindedness, (5) critical-mindedness, (6)

objectivity, (7) honesty, (8) humility, and (9) responsibility.

The instrument of assessment has been through the instrument's feasibility test, namely content validity and empirical testing by empirical validity and reliability analysis.

Conclusion

The SSA questionnaire through construct validity meets the total average score of 3.97 and includes excellent categories. Through empirical tests, Cronbach's Alpha value of the SSA questionnaire meets 0.75; which is bigger than 0.60. That means all of the statement items in the SSA questionnaire were reliable and consistent. Moreover, based on Product Momen Pearson analysis known that, for each statement item, $r_{count} > r_{table}$: 0.138 (n = 206; α = 0.05). That means all of the statement items in the SSA questionnaire, are valid to use.

The instrument feasibility, by construct validity and by empirical testing which consists of Cronbach's Alpha value and Product Momen Pearson analysis, is valid to use and reliable and consistent.

Acknowledgments

We would like to thank to all the parties that help to complete the research entitled "Assessment: The Quality of Instrument to Measure Student's Scientific Attitude (SSA) based on Content Validity and Empirical Testing".

Author Contributions

Alexander Andi Kurnianto: develop research topics and establish research procedures, analyze research data, and writing articles.

Mundilarto: Assist in develop research topics and establish research procedures.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

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