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Research Artikel

DEVELOPMENT OF SCIENTIFIC PROCESS-CREATIVE SKILLS (SP-CS) TEST ON LIGHT WAVE CONCEPT: CONTENT VALIDITY AND RASCH MODEL ANALYSIS

Royhanun Athiyyah[1*], Selly Feranie[2], Taufik Ramlan Ramalis[3]
[1,2,3]Departemn Pendidikan Fisika, Universitas Pendidikan Indonesia, Indonesia
tiaroyhanun@gmail.com [1*]

Abstract

Most creativity assessments are carried out in general fields, whereas creativity assessments in specific fields are rarely carried out. This study aims to develop a scientific creative skills test instrument that is integrated with a scientific process skills test instrument (SP-CS test) on the light waves concept. This study used the ADDIE procedure. The research procedure consists of five stages including analyzing, designing, developing, implementing, and evaluating. The initial draft of SP-CS test consisted of 21 multiple choice scientific process skills (SPS) questions and 15 open-ended scientific creative skills (SCS) questions. The results of the expert judgement were analyzed using the content validity index (CVI) and obtained a value of 0.75 (very suitable) for the SPS instrument and 0.60 (suitable) for the SCS instrument. After being revised based on the expert suggestions, the test instrument was tested on 33 students (20 girls,13 boys) aged 17-18 years. The trial data were analyzed using the Rasch Model to obtained item fit (validity), reliability, distinction level, and difficulty level. The results show that 19 of the 21 questions of SPS instrument have item validity and 14 of 15 questions of SCS instrument have item validity. Besides that, the item reliability of the SPS and SCS test instrument is 0.79 and 0.91, respectively. Meanwhile, the person reliability is 0.82 (SPS) and 0.91 (SCS). Therefore, the SP-CS test is valid and reliable so that it can be used to measure scientific process skills and scientific creative skills of students in further research.

***Keywords**: Scientific process skills; scientific creative skill; light wave; test instrument; rasch model.*

Abstrak

Asesmen kreativitas banyak dilakukan dalam bidang yang umum, sedangkan asesmen kreativitas pada bidang yang spesifik masih jarang dilakukan. Penelitian ini bertujuan mengembangkan tes *scientific creativity skills* yang diintegrasikan dengan tes *scientific process skills* (*SP-CS test*) pada konsep gelombang cahaya. Penelitian ini menggunakan prosedur ADDIE. Prosedur penelitian terdiri dari lima tahap yaitu menganalisis, merancang, mengembangkan, mengimplementasikan, dan mengevaluasi. Draf awal tes SP-CS terdiri dari 21 soal pilihan ganda scientific process skills (SPS) dan 15 soal uraian scientific creative skills (SCS). Hasil penilaian ahli dianalisis menggunakan indeks validitas isi (CVI), diperoleh nilai 0,75 (sangat sesuai) untuk instrumen SPS dan 0,60 (sesuai) untuk instrumen SCS. Setelah direvisi berdasarkan saran ahli, instrumen tes diujicobakan pada 33 siswa (20 perempuan, 13 laki-laki) berusia 17-18 tahun. Hasil uji coba dianalisis menggunakan Model Rasch untuk memperoleh kecocokan butir (validitas), reliabilitas, daya pembeda, dan tingkat kesukaran. Hasil penelitian menunjukkan bahwa 19 dari 21 butir instrumen tes SPS dan 14 dari 15 butir instrumen tes SCS memiliki validitas item. Selain itu, reliabilitas butir soal instrumen tes SPS dan SCS berturut-turut adalah 0,79 dan 0,91. Sedangkan, reliabilitas responden sebesar 0,82 (SPS) dan 0,91 (SCS). Oleh karena itu, tes SP-CS ini valid dan reliabel sehingga dapat digunakan untuk mengukur keterampilan proses ilmiah dan keterampilan kreatif ilmiah siswa dalam penelitian selanjutnya.

Kata Kunci: *Keterampilan proses sains; keterampilan kreatif ilmiah; gelombang cahaya; instrumen tes; Rasch model.*

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*Corresponding author

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INTRODUCTION

Creativity is a special need in studying science. Becoming an expert in the field of science, does not only need to master a certain amount of knowledge or be able to carry out a series of experiments following certain procedures. However, one must also have the ability to think of various solutions to gain an understanding of science. Scientific research requires creativity to generate ideas, new understanding, new ways to complement or improve existing knowledge and techniques (Hu & Adey, 2010). Like scientists, they formulate theories and laws through a series of experiments that have never been done before. They think and then follow up on their ideas to produce an original work that has a wide impact.

Compared to general creativity, scientific creativity has not been done much (Kind & Kind, 2007; Odden & Caballero, 2019; Scratchley et al., 2016). The number of general creativity studies is due to the availability of instruments to measure creativity (Hu & Adey, 2010). However, general creativity tests cannot be used to measure creativity in certain specific fields. This is because creativity is a specific domain (Chin & Siew, 2015; Han, 2003; Kaufman et al., 2008). Sternberg's research states that the correlation coefficient between creativity in different research fields is low, at 0.37 (Hu & Adey, 2010). This shows that a creativity test instrument diesigned for certain content and for respondents with a certain age extend cannot be utilized to measure creativity in other content or completely different age ranges of respondents. So it is necessary to develop scientific creative thinking test instruments in various content, especially in science.

Mumford also stated that to be able to solve problems or provide creative solutions in certain situations, one must have a knowledge base that is well organized and when needed can be fluency and efficient repeated (Mumford et al., 1991).

Science process skills are basic skills in conducting scientific experiments. There is also a lot of literature which states that science process skills are basic skills to achieve a higher level of ability including creativity. There are aspects of science process skills that correspond to aspects of scientific creativity. For example, the skills of observing, predicting, and designing experiments correspond to the components of scientific creativity (Meador, 2003). It shows the interrelationship between scientific processes and scientific creativity, as well as science education to provide the theoretical basis for a scientific problem (Gupta & Sharma, 2019). In solving a scientific problem, students explore their knowledge and then combine it with imagination and skills to produce a variety of new, different solutions.

In the process of learning science, science process skills and scientific creativity are needed. The important thing in learning science is not only about the knowledge that students acquire, but also how students can acquire that knowledge and how to use that knowledge to produce solutions to solve existing problems. When scientists undertake research; they use several scientific process skills, creativity and imagination at every phase of their investigations (Hadzigeorgiou et al., 2012). For example on the concept of light waves. By experiment, E. Malus stated that the intensity of polarized light passing through a polarizer depends on the angle between the direction of oscillation of the incident light and the axis of the polarizer. The experimental results can be expressed in equation 1 (Giancoli, 2014).

$$I = I_0 cos^2\theta \quad (1)$$

Most studies develop creativity test instruments on general topics. This study aims to develop a creativity test instrument on a science topic. In addition, this study developed a science process skills test instrument with the same topic. Thus, a set of scientific process-creative skills test instruments (SP-CS tests) can be produced which can be used to measure the correlation between scientific process skills and scientific creative skills on the topic of light waves in further research.

METHOD

This study used the ADDIE procedure that consists of five stages including analyzing, designing, developing, implementing, and

evaluating. The researcher develops a set test instrument that can measure scientific process skills and scientific creative skills (SP-CS test). The researcher also conducted a content validity test to five experts. Furthermore, the instrument improved based on expert suggestions before was implemented to the students. After implementation, all students' response was evaluated using Rasch analysis with the help of Ministep 9.3.1.0 software.

The participants of this research are the 12th-grade public high school students who are locating in Cikarang, Bekasi Regency, Indonesia. This A-accriditate public high school has been established since 1975. Most of the students in Bekasi Regency are a mix of Sundanese and Betawi ethnic. The participants were 33 students (20 females, 13 males) aged 17-18 years.

The test instrument developed was the scientific process skills (SPS) test instrument consisting of 21 multiple choice questions and the scientific creative skills (SCS) test instrument consisting of 15 open-ended questions. The SPS test instrument includes seven aspects, there are observing, interpreting, predicting, experiment planning, communicating, concept applying, and inferring. The SCS indicator refers to the Scientific Structure Creativity Model (SSCM) rubric developed by Weiping Hu and Philip Adey. In addition, there is an expert assessment rubric for content validity.

The test instrument that has been made is reviewed by five experts. The results of the expert assessment were analyzed using CVI (content validity index) developed by Lawshe (1975). Then, the test instrument was improved based on the suggestions and comments of the experts. After being revised, the test instrument was tested on 33 students. Then the test results were analyzed using the Rasch Model.

The analysis of the test instruments includes item fit, reliability, distinction level, and difficulty level. The item fit level can be determined based on the outfit means-square ($0.5<MNSQ<1.5$), outfit z-standard ($-2.0<ZSTD<2.0$), and point measure correlation ($0.4<$Pt Measure Corr<0.85). Items are very appropriate if they meet the criteria for MNSQ, ZSTD, and PT Measure Corr scores. However, items can still be accepted if they meet at least one of the three scores (Sa'diyah et al., 2020).

The point measure correlation shows the correlation of the difficulty of each item with the overall test difficulty. A value of 1 indicates that all low-ability students answered incorrectly and all high-ability participants answered correctly. Meanwhile, a value of 0 indicates no correlation between item responses. That is, the student's response does not indicate the ability of the students (Smiley, 2015).

The difficulty level of item also shows the characteristics of an instrument. The standard value of this analysis based on the value of Standard Deviation (SD) that obtained from the analysis. The SD value indicates a wide dispersion of the logit size in item difficulty. The item difficulty classified into 5 categories: very difficult (JMLE Measure $\geq$ mean logit + 2SD), difficult (mean logit + 2SD > JMLE Measure $\geq$ 1SD), moderate (1SD > JMLE Measure $\geq$ mean logit), easy (mean logit > JMLE Measure $\geq$ -1SD), and very easy (JMLE Measure < -1SD) (Soeharto & Csapó, 2022)

RESULTS AND DISCUSSION

Analyzing

The research begins with a study of literature related to scientific process skills (SPS) and scientific creative skills (SCS). After analyzing the literature, the researcher determined how the test instrument was developed. The researcher determines the Scientific Structure Creativity Model (SSCM) rubric as a reference in developing the SCS test instrument. Meanwhile, the development of the SPS test instrument includes aspects of observing, interpreting, predicting, planning experiments, communicating, applying concepts, and concluding. Light waves were chosen as the physics content for which the SPS and SCS test instruments will be developed.

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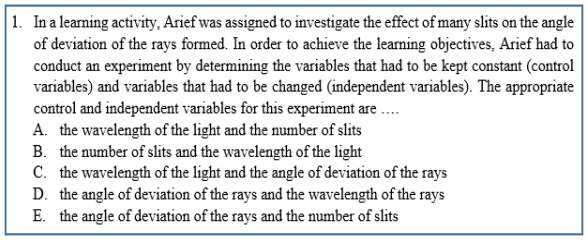
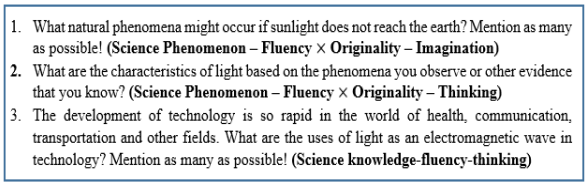
Designing

On this stage, the researchers developed indicators for SPS and SCS test instrument. The indicators are developed based on the aspects observed. For Science Process Skills, aspects that are observed include observing, interpreting, predicting, planning experiments, communicating, applying concepts, and concluding. Meanwhile, for creative thinking skills, the aspects observed include fluency, flexibility, and originality. Furthermore, the SPS and SCS items are made based on indicators. The SPS test instrument consists of 21 multiple choice questions, while the SCS test instrument consists of 15 open-ended questions. We expect that open-ended question for SCS test instrument give opportunities for creativity students, in that there is no single right answer (Odden & Caballero, 2019). Example of SPS and SCS item can be seen in Figure 1.


1. In a learning activity, Arief was assigned to investigate the effect of many slits on the angle of deviation of the rays formed. In order to achieve the learning objectives, Arief had to conduct an experiment by determining the variables that had to be kept constant (control variables) and variables that had to be changed (independent variables). The appropriate control and independent variables for this experiment are ….
   A. the wavelength of the light and the number of slits
   B. the number of slits and the wavelength of the light
   C. the wavelength of the light and the angle of deviation of the rays
   D. the angle of deviation of the rays and the wavelength of the rays
   E. the angle of deviation of the rays and the number of slits

(a)


1. What natural phenomena might occur if sunlight does not reach the earth? Mention as many as possible! **(Science Phenomenon – Fluency × Originality – Imagination)**
2. What are the characteristics of light based on the phenomena you observe or other evidence that you know? **(Science Phenomenon – Fluency × Originality – Thinking)**
3. The development of technology is so rapid in the world of health, communication, transportation and other fields. What are the uses of light as an electromagnetic wave in technology? Mention as many as possible! **(Science knowledge-fluency-thinking)**

(b)

Figure 1. Example of Test Instrument (a) Scientific Process Skills (b) Scientific Creative Skills

Developing

On developing stage, the researcher improved the SPS and SCS test instruments which were developed based on comments and suggestions from experts. The results of the expert assessment of the SPS and SCS test instruments as a whole obtained CVI scores of 0.75 and 0.60, respectively. CVI is an item statistic that is useful in the rejection or retention of a particular item. The larger the CVR is 0, the more "appropriate" the item is (Lawshe, 1975). Comments and suggestions given by experts can be seen in Tables 1 and 2.

Table 1. Comments and Suggestions on SPS Test Instruments

Expert	Comments and Suggestions for SPS Test Instruments	Follow-up
1	Revision of the item indicator editor (item 6, 11, 12, 15, 17, 18, 19, 21)	Revised
2	No comments and suggestions. Give annotations to the tool image (item 2)	Revised
3	We recommend adding more pictures to clarify the phenomena presented (item 13) Requires image improvement (item 2, 3, 4)	Revised
4	Revision of editorial items (item 3, 5, 6, 7, 8, 11, 18) Revision of editorial indicator items (item 11 & 12) Give annotations to the tool image (item 2)	Revised
5	Refine the picture of the interference phenomenon to see the difference (item 3) Revision of editorial items (item 14, 18)	Revised

Tabel 2. Comments and Suggestions on SCS Test Instruments

Expert	Comments and Suggestions for SCS Test Instruments	Follow-up
1	Revision of editorial items (item 3, 7) Not in line with the originality aspec (item 4) The question is irrelevant to the concept of polarization (item 5)	Revised
2	‘mentioning’ on the indicators is included in thinking low, it is better to replace 'mentioning' with another KKO.	Revised
3	Revision of editorial indicator items (item 1)	Revised
4	Revision of editorial indicator items and editorial items (item 1, 3, 4, 5, 8, 11, dan 14) Adjust the value/unit in the question text with the value/unit in the picture (item 8) Should not include commercial product names (item 9) Predicted answers do not match the indicators and questions (item 11)	Revised

5	Revision of indicator items (item 4 dan 8)	Revised

The suggestions of experts cover aspects of the material and language used in the items and its indicators and include the constructs of the items. The researcher revised the test instrument before giving the test to students.

Implementing

The improved SPS and SCS test instruments were tested on 33 12th-grade public high school students. Students can access SPS questions online using a PC or smartphone. Meanwhile, for testing the SCS test instrument using a paper-based test system. The time allocation for doing the SPS and SCS tests (SP-CS test) is 100 minutes.

Evaluating

The scores of each student were analyzed using ministep software to determine item validity, reliability, distinction level, and difficulty level. The scores for MNSQ outfit, ZSTD outfit, and PT-Measure Corr. of Scientific Process Skills items are shown in the Table 3.

Table 3. The Interpretation of Scientific Process Skills Item Fit and Distinction Level

SPS Aspect	Item Number	Outfit		PT-Measure Corr.	Item Fit Interpretation	Distinction Level Interpretation
		MNSQ	ZSTD			
Experiment Planning	P1	0.98	0.02	0.46	Accepted	Very Good
	P2	0.75	-0.65	0.55	Accepted	Very Good
Inferring	P3	0.42	-1.68	0.76	Accepted	Very Good
Observing	P4	1.13	0.46	0.44	Accepted	Very Good
Predicting	P5	0.48	-1.37	0.68	Accepted	Very Good
Interpreting	P6	0.96	-0.06	0.49	Accepted	Very Good
Concept Applying	P7	0.83	-0.57	0.56	Accepted	Very Good
	P8	3.60	3.23	-0.13	Not Accepted	Insufficient
Interpreting	P9	0.46	-0.74	0.63	Accepted	Very Good
Predicting	P10	0.74	-1.00	0.62	Accepted	Very Good
Communicating	P11	0.81	-0.52	0.57	Accepted	Very Good
	P12	0.76	-0.55	0.52	Accepted	Very Good
Inferring	P13	0.48	-2.17	0.77	Accepted	Very Good
Observing	P14	0.92	-0.19	0.49	Accepted	Very Good
Experiment Planning	P15	1.48	1.17	0.32	Accepted	Good
Observing	P16	0.70	-0.78	0.66	Accepted	Very Good
Communicating	P17	3.68	4.12	-0.38	Not Accepted	Insufficient
Concept Applying	P18	1.25	0.95	0.35	Accepted	Good
Interpreting	P19	0.42	-1.60	0.73	Accepted	Very Good
Predicting	P20	0.95	-1.10	0.49	Accepted	Very Good
Inferring	P21	1.32	0.73	0.37	Accepted	Good

From the table, it can be seen that items P8 and P17 do not meet the three scores, so it can be said that the items do not have item fit. While, the others meet at least one of these criteria so that it can be said that the items have item fit. Furthermore, PT-Measure corr. shows the distinction level of the item. Item P8 and P15 each have negative pt measure corr values, meaning the item should be checked to see whether the answer key was wrong, revised, or possibly deleted from the test (Smiley, 2015). While, the other 19 items have a PT-Measure Corr. value close to one. The closer to one, the better the distinction level. The scores for MNSQ outfit, ZSTD outfit, and PT-Measure Corr. of Scientific Creative Skills items are shown in the Table 4.

Table 4. The interpretation of Scientific Creative Skills Item Fit and Distinction Level

SCS Aspect	Item Number	Outfit		PT-Measure Corr.	Item Fit Interpretation	Distinction Level Interpretation
		MNSQ	ZSTD			
Fluency, Originality	E1	1.01	0.13	0.65	Accepted	Very Good
	E2	0.53	-2.16	0.81	Accepted	Very Good
Fluency	E3	0.70	-1.11	0.72	Accepted	Very Good
	E4	0.66	-0.75	0.46	Accepted	Very Good
	E5	1.08	0.33	0.38	Accepted	Good
Flexibility, Originality	E6	1.39	1.38	0.54	Accepted	Very Good
Fluency	E7	1.24	0.86	0.42	Accepted	Very Good
Originality	E8	0.96	0.18	0.26	Accepted	Sufficient
Flexibility, Originality	E9	1.00	0.08	0.59	Accepted	Very Good
	E10	0.83	-0.45	0.48	Accepted	Very Good
Fluency, Originality	E11	0.77	-0.69	0.51	Accepted	Very Good
Flexibility	E12	2.04	2.35	0.04	Not Accepted	Insufficient
Fluency	E13	0.70	-1.25	0.65	Accepted	Very Good
Flexibility, Originality	E14	1.10	0.43	0.51	Accepted	Very Good
Originality	E15	0.52	-1.00	0.63	Accepted	Very Good

Based on Table 4, the item that does not have item fit is E12 because it does not meet the three scores. While, the others meet at least one of these criteria so that it can be said that the items have item fit and can be used for research related to the identification of students' scientific creative skills. Meanwhile, 14 items have a PT-Measure Corr. value close to one. It shows the item has distinction level. However, one item has a value of almost zero so it can be said that the item has no distinction level. In the SCS test instrument, student test results are assessed based on the rubric that has been made and is assessed with a score range of 0-3. The assessment of the fluency aspect is based on the number of answers given by students without considering the quality of the answers. The assessment of the flexibility aspect is based on the number of approaches or students' perspectives in providing answers. The assessment of originality is done by tabulating the frequency of all student answers. Score 3 is obtained if the answers given are less than 5% of all answers. Score 2 is obtained if the answers are in the range of 5% -10% of all answers. Score 1 is obtained if the answers given are more than 10% of all answers (Hu & Adey, 2010).

Farther, Ministep Software will generate person reliability, item reliability and Cronbach's Alpha (α). The summary statistic of SPS and SCS test instrument shown in Table 5.

Table 5. Summary Statistic of Measured Item and Person for each SPS and SCS Test Instrument

	SPS		SCS	
	Item	**Person**	**Item**	**Person**
N	21	33	15	33
Mean	14.7	9.4	71.4	32.5
Mean Measure	0.00	-0.30	0.00	-0.56
P.SD	0.99	1.29	1.07	1.01
Mean Outfit MNSQ	1.10	1.10	0.97	0.97
Mean Outfit ZSTD	-0.06	-0.01	-0.11	0.04
Reliability	0.79	0.80	0.91	0.82
Cronbach's alpha		0.83		0.86

The Rasch model showed good person and item reliability values for SPS items, which were 0.80 and 0.79, respectively. While the person and item reliability value for SCS test instruments were 0.82 and 0.91, respectively (values higher than 0.67 indicate good reliability) (Fisher, 2007). These results show that both of SPS and SCS test instruments are reliable to identified the scientific process skills and scientific creative skills of students (Sa'diyah et al., 2020). The person reliability scores are not too different, it shows the seriousness of the students in doing the SP-CS test (Dewi et al., 2021). Furthermore, the quality of interaction between the person and items illustrated by Cronbach Alpha value, which were scored 0.83 (good) for SPS test instruments and 0.86 (good) for SCS test instruments. The values indicating high internal consistency and reliability (Taber, 2018). Farther, the results of difficulty level analysis on SPS test instruments can be seen in the Table 6.

Tabel 6. Difficulty Level of SPS Test Instruments

Entry Number	**JMLE Measure**	**Difficulty Level Interpreation**
9	1.93	Difficult
8	1.40	Difficult
21	1.40	Difficult
3	0.97	Moderate
15	0.97	Moderate
17	0.97	Moderate
16	0.77	Moderate
1	0.23	Moderate
13	0.23	Moderate
18	0.06	Moderate
10	-0.10	Easy
7	-0.26	Easy
20	-0.26	Easy
6	-0.58	Easy
14	-0.58	Easy
11	-0.91	Easy
2	-1.08	Very Easy
4	-1.08	Very Easy
12	-1.25	Very Easy
5	-1.42	Very Easy
19	-1.42	Very Easy
Mean	0.00	
P. SD	0.99	

Table 6 shows the score of JMLE Measure from the highest to the lowest. The bigger score of JMLE Measure, the more difficult item and vice versa. On the SPS test instrument, there are three

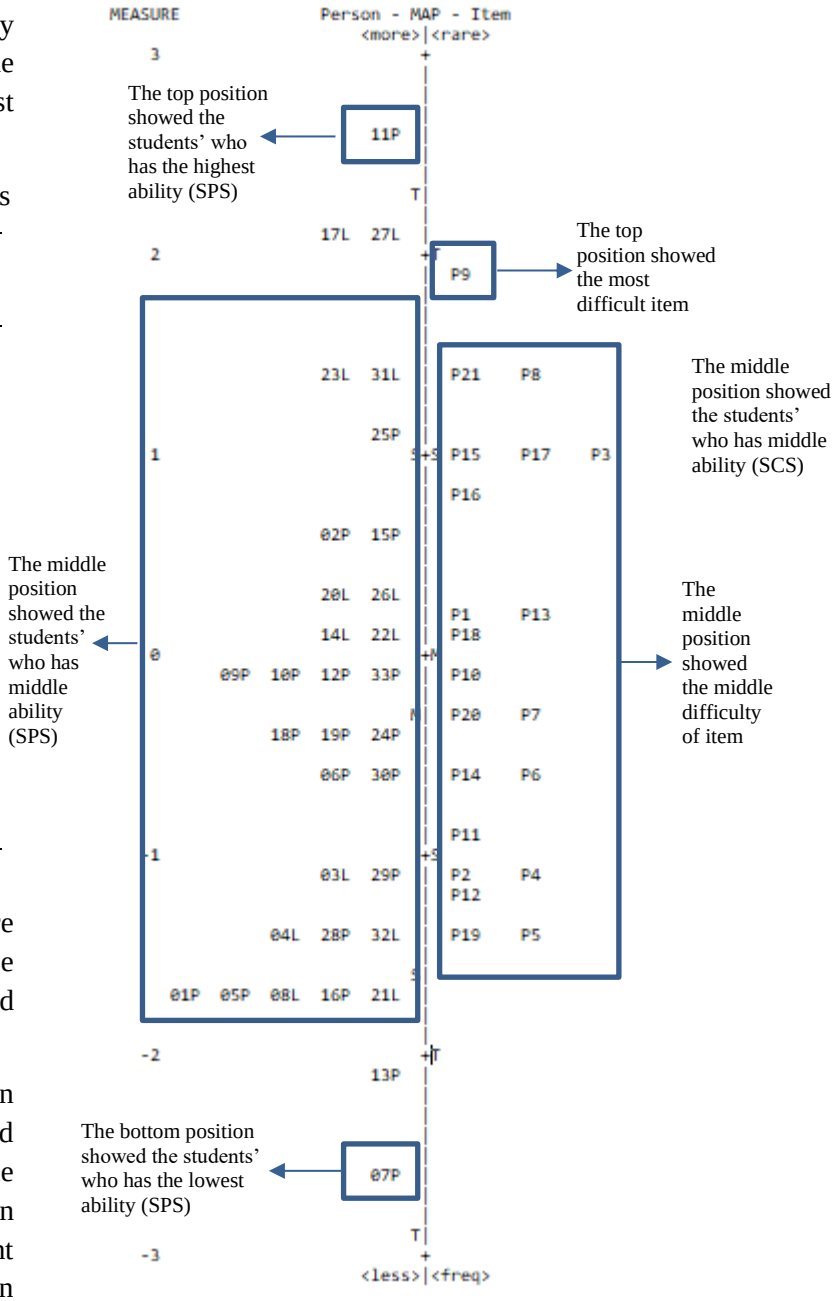
difficult items, seven moderate items, six easy items, and 5 very easy items. Meanwhile, the results of difficulty level analysis on SCS test instruments can be seen in the Table 7.

Tabel 7. Difficulty Level of SCS Test Instruments

Entry Number	JMLE Measure	Difficulty Level Interpreation
8	1.74	Difficult
5	1.45	Difficult
4	1.28	Difficult
12	0.74	Moderate
11	0.55	Moderate
10	0.43	Moderate
15	0.37	Moderate
14	-0.09	Easy
7	-0.23	Easy
6	-0.40	Easy
13	-0.63	Easy
2	-0.77	Easy
9	-0.80	Easy
3	-1.28	Very Easy
1	-2.36	Very Easy
Mean	0.00	
P. SD	1.07	

Table 7 shows the score of JMLE Measure from the highest to the lowest. There are three difficult items, 4 moderate items, 6 easy items, and 2 very easy items.

The analysis of the Rasch model can describe the distribution of students' abilities and the difficulty level of items with the same scale (Sumintono & Widhiarso, 2015). The distribution is depicted in the form of a map called the wright map. The result of wright map can be seen on Figure 2.



(a)

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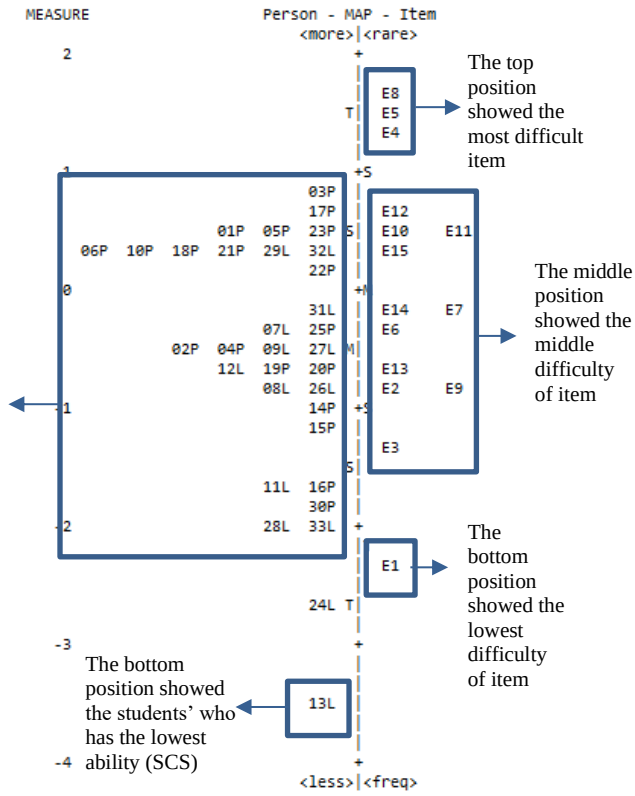

(b)

Figure 2. Wright Map for (a) SPS test instruments (b) SCS test instruments

The figure 2 above show about of the wright maps of items and persons. Outline item showed on the right side, while the outline person appeared on the left side. Based on the outline showed that participant almost has a medium ability on scientific process skills and scientific creative skills.

Based on the analysis of item fit, reliability, distinction level, and difficulty level using the Rasch Model, the SPS and SCS test instruments developed can be said to be valid and reliable. Therefore, the both of SPS and SCS test instrument (SP-CS test) can be used to measure scientific process skills and scientific creative skills in further research

CONCLUSION

The scientific process skills test instrument developed consisted of 21 multiple choice questions, but only 19 items had item fit validity. From the 19 valid items, the distinction level of 16 items was in the very good category, while the other three items were in the good category. The person and item reliability of the SPS test instrument as a whole obtained a score of 0,80 and 0.79 in the good category. For the scientific creative skills test instrument that was developed, there were 15 open-ended questions, but only 14 questions had item fit. From the 14 valid items, the distinction level of 12 items is in the very good category, an item in the good category, and an item in the sufficient category. The person and item reliability of the SCS test instrument as a whole obtained a score of 0.82 and 0.91 in the good category. The quality of interaction between the person and items illustrated by Cronbach Alpha value, the SPS test instrument scored 0.83 (good) and the SCS instrument scored 0.86 (good). Therefore, the SP-CS test which consists of 19 multiple choice questions and 14 open-ended questions is valid and reliable so that it can be used to measure students' scientific process skills and scientific creative skills in further research.

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 | p-ISSN 1979-7281 | e-ISSN 2443-1281

Lampiran

Rubrik Penilaian Instrumen Tes SCS

No Soal	Aspek SCS	Indikator Soal	Kriteria	Skor
1	*Science Phenomenon – Fluency* × *Originality – Imagination*	Memprediksi sebanyak mungkin gejala alam yang terjadi jika cahaya matahari tidak sampai ke bumi.	**Fluency**	
			Memberikan 3 atau lebih gejala alam	3
			Memberikan 2 gejala alam	2
			Memberikan 1 gejala alam	1
			Tidak ada jawaban	0
			Originality	
			Gejala alam yang diberikan termasuk ke dalam <5% dari jawaban yang diberikan	3
			Gejala alam yang diberikan termasuk ke dalam 5 - 10% jawaban yang diberikan	2
			Gejala alam yang diberikan termasuk ke dalam > 10% dari jawaban yang diberikan	1
			Tidak ada jawaban	0
2	*Science Phenomenon – Fluency* × *Originality – Thinking*	Memberikan berbagai karakteristik gelombang cahaya berdasarkan fenomena alam yang diamati atau berdasarkan pengetahuan sebelumnya.	**Fluency**	
			Memberikan 3 atau lebih karakteristik beserta fenomenanya	3
			Menyebutkan 2 karakteristik beserta fenomenanya	2
			Menyebutkan 1 karakteristik beserta fenomenanya	1
			Tidak ada jawaban	0
			Originality	
			Karakteristik dan fenomena alam yang diberikan termasuk ke dalam <5% dari jawaban yang diberikan	3
			Karakteristik dan fenomena alam yang diberikan termasuk ke dalam 5% - 10% jawaban yang diberikan	2
			Karakteristik dan fenomena alam yang diberikan termasuk ke dalam >10% dari jawaban yang diberikan	1
			Tidak ada jawaban	0
3	*Science Knowledge – Fluency – Thinking*	Memberikan berbagai contoh pemanfaatan gelombang cahaya sebagai gelombang elektromagnetik dalam teknologi.	**Fluency**	
			Memberikan 3 atau lebih manfaat gelombang cahaya	3
			Memberikan 2 manfaat gelombang cahaya	2
			Memberikan 1 manfaat gelombang cahaya	1
			Tidak ada jawaban	0

4	*Science Knowledge – Fuency – Thinking*	Memberikan berbagai alasan mengapa api merah sebaiknya diubah menjadi api biru.	**Fluency**	
			Memberikan 3 atau lebih kelebihan api biru dibandingkan api merah	3
			Memberikan 2 kelebihan api biru dibandingkan api merah	2
			Memberikan 1 kelebihan api biru dibandingkan api merah	1
			Tidak ada jawaban	0
5	*Science Pheomenon – Fluency – Thinking*	Memberikan contoh berbagai kondisi yang memperlukan polarisasi cahaya.	**Fluency**	
			Memberikan 3 atau lebih kondisi yang membutuhkan polarisasi cahaya	3
			Memberikan 2 kondisi yang membutuhkan polarisasi cahaya	2
			Memberikan 1 kondisi yang membutuhkan polarisasi cahaya	1
			Tidak ada jawaban	0
6	*Technical Product – Flexibility × Originality – Thinking*	Memberikan berbagai cara untuk mengurangi intensitas cahaya.	***Flexibility***	
			Memberikan berbagai cara untuk mengurangi intensitas cahaya. 3 atau lebih cara untuk mengurangi intensitas cahaya	3
			Memberikan berbagai cara untuk mengurangi intensitas cahaya. 2 cara untuk mengurangi intensitas cahaya	2
			Memberikan berbagai cara untuk mengurangi intensitas cahaya. 1 cara untuk mengurangi intensitas cahaya	1
			Tidak ada jawaban	0
			Originality	
			Jawaban yang diberikan termasuk ke dalam <5% dari jawaban yang diberikan	3
			Jawaban yang diberikan termasuk ke dalam 5% - 10% jawaban yang diberikan	2
			Jawaban yang diberikan termasuk ke dalam >10% dari jawaban yang diberikan	1
			Tidak ada jawaban	0
7	*Science Phenomenon – Fluency – Thinking*	Memberikan berbagai contoh fenomena yang berkaitan dengan difraksi cahaya.	***Fluency***	
			Memberikan 3 atau lebih fenomena yang berkaitan dengan difraksi cahaya	3
			Memberikan 2 fenomena yang berkaitan dengan difraksi cahaya	2
			Memberikan 1 fenomena yang berkaitan dengan difraksi cahaya	1
			Tidak ada jawaban	0

 | p-ISSN 1979-7281 | e-ISSN 2443-1281

8	*Technical Product – Originality – Thinking*	Memberikan berbagai rancangan percobaan untuk mengamati difraksi cahaya	***Originality***	
			Rancangan yang diberikan termasuk ke dalam <5% dari seluruh rancangan yang diberikan	3
			Rancangan yang diberikan termasuk ke dalam 5% - 10% seluruh rancangan yang diberikan	2
			Rancangan yang diberikan termasuk ke dalam >10% dari seluruh rancangan yang diberikan	1
			Tidak ada jawaban	0
9	*Technical Product – Flexibility × Originality – Thinking*	Memberikan cara-cara menghasilkan foto yang estetik dengan kualitas baik.	***Flexibility***	
			Memberikan 3 atau lebih cara untuk menghasilkan foto yang estetik dengan kualitas baik	3
			Memberikan 2 cara untuk menghasilkan foto yang estetik dengan kualitas baik	2
			Memberikan 1 cara untuk menghasilkan foto yang estetik dengan kualitas baik	1
			Tidak ada jawaban	0
			Originality	
			Jawaban yang diberikan termasuk ke dalam <5% dari seluruh jawaban yang diberikan	3
			Jawaban yang diberikan termasuk ke dalam 5% - 10% seluruh jawaban yang diberikan	2
			Jawaban yang diberikan termasuk ke dalam >10% dari seluruh jawaban yang diberikan	1
			Tidak ada jawaban	0
10	*Science Problem - Flexibility × Originality – Thinking*	Memberikan berbagai cara mengambil foto/gambar ketika intensitas cahaya terlalu tinggi.	***Flexibility***	
			Memberikan 3 atau lebih cara mengambil foto/gambar ketika intensitas cahaya terlalu tinggi	3
			Memberikan 2 cara mengambil foto/gambar ketika intensitas cahaya terlalu tinggi	2
			Memberikan 1 cara mengambil foto/gambar ketika intensitas cahaya terlalu tinggi	1
			Tidak ada jawaban	0
			Originality	
			Jawaban yang diberikan termasuk ke dalam <5% dari seluruh jawaban yang diberikan	3
			Jawaban yang diberikan termasuk ke dalam 5% - 10% seluruh jawaban yang diberikan	2
			Jawaban yang diberikan termasuk ke dalam >10% dari seluruh jawaban yang diberikan	1

			Tidak ada jawaban	0
11	*Science Knowledge – Fluency × Originality – Thinking*	Memberikan berbagai alasan perlunya fitur ‘perisai mata’ atau ‘perlindungan mata’ pada *smartphone*.	***Fluency***	
			Memberikan 3 atau lebih alasan perlunya fitur ‘perisai mata’ atau ‘perlindungan mata’ pada *smartphone*	3
			Memberikan 2 alasan perlunya fitur .‘perisai mata’ atau ‘perlindungan mata’ pada *smartphone*	2
			Memberikan 1 manfaat ‘perisai mata’ atau ‘perlindungan mata’ pada *smartphone*	1
			Tidak ada jawaban	0
			Originality	
			Jawaban yang diberikan termasuk ke dalam <5% dari seluruh jawaban yang diberikan	3
			Jawaban yang diberikan termasuk ke dalam 5% - 10% seluruh jawaban yang diberikan	2
			Jawaban yang diberikan termasuk ke dalam >10% dari seluruh jawaban yang diberikan	1
			Tidak ada jawaban	0
12	*Science Knowledge – Flexibility – Thinking*	Memberikan berbagai pertimbangan dalam memilih lampu untuk pencahayaan di rumah.	***Flexibility***	
			Memberikan 3 atau lebih pertimbangan dalam memilih lampu	3
			Memberikan 2 pertimbangan dalam memilih lampu	2
			Memberikan 1 pertimbangan dalam memilih lampu	1
			Tidak ada jawaban	0
13	*Science Knowledge – Fluency – Thinking*	Memberikan berbagai tujuan dari penggunaan kacamata.	***Fluency***	
			Memberikan 3 atau lebih tujuan dari penggunaan kacamata	3
			Memberikan 2 tujuan dari penggunaan kacamata	2
			Memberikan 1 tujuan dari penggunaan kacamata	1
			Tidak ada jawaban	0
14	*Science Problem – Flexibility × Originality – Thinking*	Memberikan solusi terhadap permasalahan mengenai intensitas cahaya matahari beserta pertimbangannya	***Flexibility***	
			Memberikan 3 atau lebih solusi terhadap permasalahan mengenai intensitas cahaya matahari beserta pertimbangannya	3
			Memberikan 2 solusi terhadap permasalahan mengenai intensitas cahaya matahari beserta pertimbangannya	2
			Memberikan 1 solusi terhadap permasalahan mengenai	1

 | p-ISSN 1979-7281 | e-ISSN 2443-1281

			intensitas cahaya matahari beserta pertimbangannya	
			Tidak ada jawaban	0
			Originality	
			Jawaban yang diberikan termasuk ke dalam <5% dari seluruh jawaban yang diberikan	3
			Jawaban yang diberikan termasuk ke dalam 5% - 10% seluruh jawaban yang diberikan	2
			Jawaban yang diberikan termasuk ke dalam >10% dari seluruh jawaban yang diberikan	1
			Tidak ada jawaban	0
15	*Technical Product – Originality – Thinking × Imagination*	Menghasilkan rancangan yang baru dan unik untuk mengamati interferensi cahaya pada lapisan tipis.	***Originality***	
			Jawaban yang diberikan termasuk ke dalam <5% dari seluruh jawaban yang diberikan	3
			Jawaban yang diberikan termasuk ke dalam 5% - 10% seluruh jawaban yang diberikan	2
			Jawaban yang diberikan termasuk ke dalam >10% dari seluruh jawaban yang diberikan	1
			Tidak ada jawaban	0

Kisi-kisi Instrumen Tes SPS

No.	Aspek SPS	Indikator Soal
1.	Merencanakan Percobaan	Menentukan variabel-variabel percobaan berdasarkan tujuan percobaan yang diberikan.
2.	Merencanakan Percobaan	Merangkai percobaan sederhana untuk mengamati difraksi cahaya menggunakan alat dan bahan yang tersedia.
3.	Menyimpulkan	Menyimpulkan panjang gelombang sinar berdasarkan jarak antar pola terang yang dihasilkan pada simulasi percobaan interferensi cahaya.
4.	Mengamati	Menentukan gejala yang dialami cahaya berdasarkan fenomena yang diamati.
5.	Memprediksi	Memprediksi jarak antar pola terang yang terbentuk berdasarkan sejumlah data yang diberikan
6.	Menafsirkan	Menafsirkan hubungan antara panjang gelombang cahaya dan sudut penyimpangan cahaya berdasarkan grafik yang diberikan.
7.	Menerapkan Konsep	Menerapkan konsep karakteristik cahaya tampak pada pola gelap-terang yang terbentuk dalam percobaan difraksi cahaya.
8.	Menerapkan Konsep	Menentukan sudut polarisator dan sudut analisator untuk memperoleh intensitas cahaya yang diharapkan.

9.	Menafsirkan	Menganalisis grafik hubungan antara sudut sumbu polarisator dan intensitas cahaya.
10.	Memprediksi	Menentukan panjang gelombang cahaya yang digunakan berdasarkan data yang diberikan.
11.	Mengomunikasikan	Menentukan grafik orde cahaya (n) terhadap jarak terang ke-n dari terang pusat (y) yang tepat berdasarkan data yang diberikan.
12.	Mengomunikasikan	Menentukan grafik sudut sumbu terhadap intensitas cahaya berdasarkan data yang diberikan.
13.	Menyimpulkan	Menarik kesimpulan mengenai pengaruh sudut sumbu polaroid terhadap intensitas cahaya berdasarkan gambar-gambar yang diberikan.
14.	Mengamati	Menentukan kelebihan hasil foto menggunakan filter polarisasi berdasarkan kedua gambar yang disajikan.
15.	Merencanakan Percobaan	Mengurutkan langkah percobaan polarisasi cahaya yang tepat berdasarkan tujuan percobaan yang diberikan.
16.	Mengamati	Membaca hasil pengukuran jarak pola gelap-terang interferensi cahaya berdasarkan gambar yang diberikan.
17.	Mengomunikasikan	Membuat tabel hasil percobaan kisi difraksi berdasarkan data percobaan yang diberikan.
18.	Menerapkan Konsep	Menerapkan persamaan interferensi Young untuk memperoleh nilai panjang gelombang cahaya.
19.	Menafsirkan	Menganalisis pengaruh jumlah celah terhadap sudut penyimpangan θ berdasarkan data yang diberikan.
20.	Memprediksi	Menentukan intensitas cahaya akhir berdasarkan sejumlah data yang diberikan.
21.	Menyimpulkan	Memberikan kesimpulan mengenai hubungan antara jarak sumber cahaya (d) dan jarak antar pola terang (Δy) berdasarkan gambar yang diberikan.

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