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Assessing Creative Thinking Skills of MTs Students in Solving Renewable Energy Problems: A Binomial Test Analysis

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ABSTRACT

This study aims to analyse the proportion of creative thinking ability of MTs students on the topic of renewable energy using binomial test statistics. Students' creative thinking ability was measured based indicators of Torrance Tests of Creative Thinking (TTCT): fluency, flexibility, originality, and elaboration. The sample consisted of 109 students selected from four MTs in South OKU District selected by random sampling. The research instrument was in the form of multiple choice questions which were previously tested for validity using the Rasch Item Fit Model analysis and instrument reliability of 0.55. Although not a very high value, this result can still be used for exploratory purposes in the evaluation of the instrument. The data were then analysed using the binomial test with an expected proportion of 50%. The binomial test is used because the data is dichotomous. Results indicated that the highest average score was achieved in fluency (60.54), while the lowest was in originality (22.52). Only 36% of students who can answer more than 50% of the questions correctly, while 64% of students have not managed to reach the expected standard. The binomial test results indicated that the proportion of students who were able to solve renewable energy problems creatively was significantly lower than the expected value ($p = 0.004 < 0,05$). This finding suggests that students' creative thinking skills are still uneven, influenced by factors such as teacher-centred learning methods, lack of practical exploration, and limited understanding on the topic of renewable energy.

Keywords : Creative Thinking, Renewable Energy, Binomial Test, TTCT.

I. INTRODUCTION

21st century education requires students to master various skills, one of which is the ability to think creatively which is an essential component in facing global challenges. Creative thinking ability is one of the higher order thinking skills [1-2]. According to Torrance, creative thinking involves a multi-stage process: identifying problems or gaps in knowledge, generating possible solutions or hypotheses, testing and refining them, and ultimately communicating the findings [3]. With creative thinking skills, students can solve problems by creating unique, different, and logical ideas [4]. Students who have creative thinking skills are not only proficient in science, but also quite ready in the technological era [5].

However, based on the results of the PISA 2022 international study, it shows that the average score of creative thinking skills of Indonesian students is still low, which is only 19 out of 60 OECD average points. This study focuses on students at Madrasah Tsanawiyah (MTs), where science education often lacks opportunities for students to develop creative thinking due to teacher-centred instructional methods. These methods tend to make students passive and less involved in critical or creative thinking processes [6]. The varied geographical conditions of the region and the limited educational infrastructure also affect the distribution of education quality. In fact, science learning should be a vehicle for developing analytical thinking skills that allow students to solve complex problems [7]. According to the 2019 TIMSS (Trends in International Mathematics and Science Study) report, Indonesian students are ranked at the bottom in terms of critical and creative thinking skills in science subjects [8].

Renewable energy is an important topic that provides opportunities for students to apply creative thinking in addressing real-world challenges like climate change and fossil fuel depletion [9]. This topic provides an opportunity for students to train students to think creatively in finding innovative solutions to global problems [10]. The importance of teaching students about renewable energy is to introduce environmentally friendly technologies [11], as well as to reduce dependence on fossil energy sources that may be replaced in 2050 [12]. Research shows that learning about renewable energy can contribute to the achievement of the Sustainable Development Goals (SDGs), particularly in the aspects of quality education and climate action [13]. South OKU District has natural potentials that support the development of renewable energy, such as large rivers that can be used for hydroelectric power plants (PLTA) and vast land suitable for solar energy development. However, the lack of students' awareness and understanding of the utilisation of this potential is one of the challenges in science learning in madrasah.

To analyze students' performance in solving renewable energy-related problems, a binomial test was employed. This non-parametric test is suitable for dichotomous data and used to assess whether the proportion of correct answers differs significantly from an expected value. The binomial test is usually used in preference tests with the assumption that the choices are independent and the probabilities of the choices do not vary [14]. The binomial test was chosen because students' answers to the creative thinking questions were assessed on a dichotomous scale, thus fulfilling the conditions for using the test. In addition, it is effective in testing proportional hypotheses without making strong normality assumptions, which makes it an appropriate choice in the context of this research sample.

Based on the description above, this study aims to examine the proportion of students who are able to solve renewable energy problems creatively. Testing this proportion is important to find out whether most students have reached the expected standard of ability or still require further intervention. The results of this study are expected to provide theoretical and practical insights to improve the quality of science learning in madrasah, as well as support the development of 21st century skills relevant to global issues.

II. METHOD

This study used a quantitative approach with a focus on analysing the proportion of students' creative thinking ability using the binomial test. This test is based on data collected based on dichotomy [15], namely correct or incorrect answers and aims to determine whether the proportion of students who can solve energy loss problems creatively is significantly different from the expectation of at least 50%. The population in this study were all grade IX MTs students in South OKU. The selection of grade IX is based on the assumption that students in this grade have completed basic science materials, including the topic of renewable energy, so they have sufficient background knowledge to be evaluated. The research sample was selected by random sampling from four MTs in South OKU.

Data were collected using a written test administered via Google Forms. The instrument consisted of 20 multiple-choice questions designed to assess four indicators of creative thinking based on the Torrance Tests of Creative Thinking (TTCT): fluency, flexibility, originality, and elaboration [16]. Each indicator was assessed by five items [16]. Each indicator is represented by five questions. Before use, the test instrument was validated using Item Fit analysis based on the Rasch model. Validity testing is the process of collecting relevant evidence to provide a scientific basis for score interpretation. Reliability test to measure the consistency of the research instrument. Evidence of validity is supported by the Item Fit Test. Item validity is determined based on the values for Outfit MNSQ and Infit MNSQ set in the range 0.7-1.3. Then the Outfit ZSTD and Infit ZSTD values are set in the range -2.0 to +2.0 [17].

For the binomial test, the initial data results in the form of multiple-choice scores were converted into a binary format: correct (1) and incorrect (0). From the 20 original items, 8 representative items (2/TTCT indicator) were selected for binomial analysis. These items were dichotomized into correct (1) or incorrect (0) responses to align with the assumptions of the binomial test. This process ensured that all creative dimensions remained represented. An expected proportion of 50% was set based on the assumption that students answering randomly would correctly answer half of the items. This value serves as a baseline to evaluate whether students' performance significantly exceeds chance level. A binomial test was conducted to test whether the proportion of students who answered correctly was significantly different from the expected value. The hypotheses in this study are:

a. H_0 : There is no significant difference between the observed proportion of MTs students who can creatively solve renewable energy problems and the expected proportion of 50%.
b. H_1 : There is a significant difference between the observed proportion of MTs students who can creatively solve renewable energy problems and the expected proportion of 50%.

III. RESULTS AND DISCUSSION

Sample Distribution

The sample was taken randomly from 4 MTs in South OKU with the entire sample totalling 109 ninth grade students. The distribution of students based on school origin is as follows.

Table 1. Distribution of sample MTs student respondents

No	Name of Madrasah	Students (people)	Percentage
1	MTs N 1 South OKU	27	24,77%
2	MTs N 2 South OKU	10	9,17%
3	MTs N 3 South OKU	36	33,03%
4	MTs Al Ittifaqiah South OKU	36	33,03%

Meanwhile, the distribution of respondents based on gender can be seen in Diagram 1.

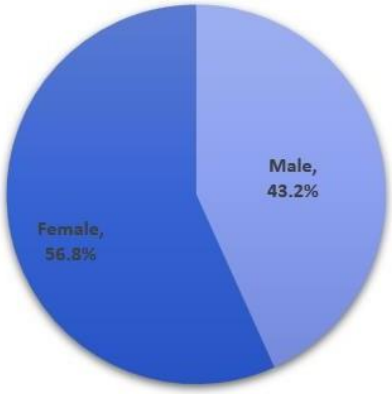

Diagram 1. Distribution of respondents based on gender

The distribution showed that females formed the majority with a proportion of 56.8%, while males accounted for 43.2%, making the distribution relatively balanced and representative for further analysis. A fairly even distribution of samples by gender school level was done to reduce regional bias in data collection. This is emphasise the importance of sample diversity in improving the generalisability of research results [18].

Instrument Validity and Reliability

The test instrument was in the form of multiple choice questions that measured creative thinking ability based on the Torrance Tests of Creative Thinking (TTCT) indicators: fluency, flexibility, originality, and elaboration. Initially, each indicator was represented by 5 questions, so the total instrument consisted of 20 questions. Validity analysis was conducted using the Rash Model Item Fit Test with validity criteria of Outfit MNSQ : 0.7 - 1.3 and ZSTD Outfit/Infit: -2.0 to +2.0 The results of the item fit test analysis are as follows:

TABLE 10.1 data untuk winstep.xlsx ZOU781WS.TXT May 05 2025 05:16
INPUT: 75 Person 20 Item REPORTED: 75 Person 20 Item 2 CATS MINISTEP 5.8.5.0

Person: REAL SEP.: 1.10 REL.: .55 ... Item: REAL SEP.: 3.78 REL.: .93

Item STATISTICS: MISFIT ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	JMLE MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PTMEASUR-AL CORR.	PTMEASUR-AL EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Item
18	6	75	2.03	.43	1.04	.23	2.40	2.14	A .00	.17	91.9	91.9	18
11	6	75	2.03	.43	.99	.09	2.31	2.05	B .08	.17	91.9	91.9	11
14	14	75	1.00	.31	1.07	.45	1.48	1.56	C .13	.25	81.1	81.0	14
13	18	75	.65	.28	1.09	.66	1.47	1.90	D .11	.27	79.7	76.0	13
6	15	75	.91	.30	1.15	.90	1.46	1.59	E .05	.25	79.7	79.7	6
8	17	75	.73	.29	1.17	1.16	1.24	1.00	F .08	.27	73.0	77.1	8
12	19	75	.57	.28	1.10	.80	1.21	.99	G .15	.28	75.7	74.8	12
9	44	75	-1.05	.25	1.08	.89	1.20	1.63	H .27	.36	64.9	65.7	9
5	17	75	.73	.29	1.05	.38	1.00	.07	I .23	.27	75.7	77.1	5
7	31	75	-.25	.25	1.00	-.03	.98	-.12	J .34	.33	70.3	65.3	7
17	34	75	-.43	.25	1.00	-.03	.95	-.40	j .35	.34	63.5	64.4	17
10	15	75	.91	.30	.96	-.21	.81	-.67	i .32	.25	79.7	79.7	10
19	48	75	-1.31	.26	.96	-.32	.95	-.29	h .41	.37	70.3	69.2	19
15	22	75	.35	.27	.92	-.70	.94	-.28	g .37	.29	74.3	71.7	15
1	45	75	-1.11	.25	.93	-.78	.90	-.84	f .44	.37	68.9	66.3	1
2	56	75	-1.90	.29	.88	-.77	.81	-.91	e .50	.38	79.7	77.6	2
20	19	75	.57	.28	.87	-.95	.82	-.83	d .40	.28	78.4	74.8	20
16	46	75	-1.18	.26	.85	-1.61	.84	-1.27	c .51	.37	70.3	67.3	16
4	53	75	-1.66	.27	.83	-1.37	.73	-1.63	b .56	.38	78.4	74.4	4
3	52	75	-1.59	.27	.82	-1.52	.73	-1.78	a .57	.38	77.0	73.3	3
MEAN	28.9	75.0	.00	.29	.99	-.14	1.16	.20			76.2	74.9	
P.SD	16.3	.0	1.18	.05	.10	.82	.46	1.26			7.2	7.6	

Fig. 1. Results of Item Fit test analysis of creative thinking skills question instruments

The results showed that most of the items met the validity criteria, except for questions number 11 and 18 which were declared missfit because the Outfit MNSQ value was outside the range. Then the reliability test was also carried out with the following results:

SUMMARY OF 75 MEASURED (EXTREME AND NON-EXTREME) Person

	TOTAL SCORE	COUNT	MODEL MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	7.7	20.0	-.69	.57				
SEM	.3	.0	.11	.02				
P.SD	2.8	.0	.93	.17				
S.SD	2.8	.0	.94	.17				
MAX.	13.0	20.0	.81	1.85				
MIN.	.0	20.0	-4.78	.51				

REAL RMSE .63 TRUE SD .69 SEPARATION 1.10 Person RELIABILITY .55
MODEL RMSE .59 TRUE SD .72 SEPARATION 1.22 Person RELIABILITY .60
S.E. OF Person MEAN = .11

Person RAW SCORE-TO-MEASURE CORRELATION = .97
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .53 SEM = 1.89
STANDARDIZED (50 ITEM) RELIABILITY = .79

Fig. 2. Results of Reability test analysis of creative thinking skills question instruments

From Figure 2, the person reliability value is 0.55, which means that the questions being used have a medium level of reliability. Although not a very high value, this result can still be used for exploratory purposes as mentioned by Boone et al. (2014) in the evaluation of educational instruments [17]. To see students' creative thinking ability, the data was analysed with the following results:

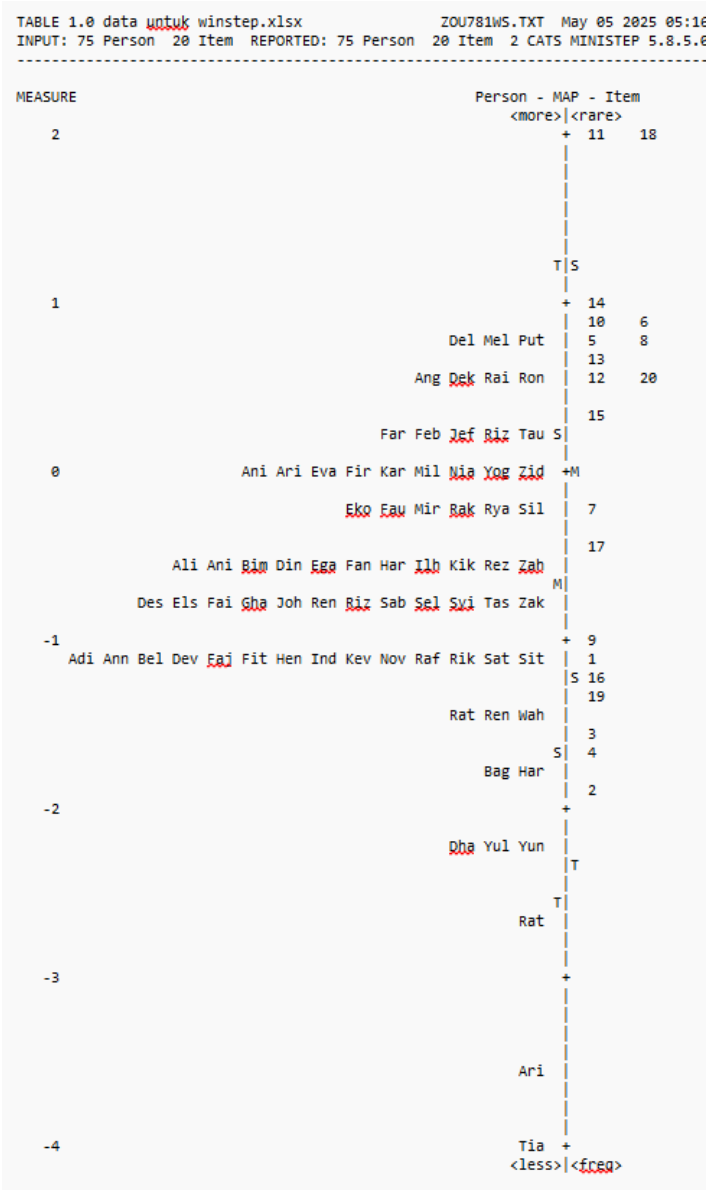

Fig. 3. The results of the analysis of students' creative thinking skills

From Figure 3, it can be seen that out of 75 students in class IX, 37 students are below the M- (Less) line. While students who are above the M+ (More) line are 38 students. This shows that the number of students is equal between those with higher and lower abilities.

Creative Thinking Ability Based on TTCT Indicators

While the level of students' creative thinking skills was analysed based on four TTCT indicators, the results can be seen in Table 2.

Table 2. Creative thinking skills test results of MTs students

Indicator	Average Score	Description of Results
Fluency	60,54	Highest; student is able to generate many ideas
Elaboration	45,77	Fairly good; student can develop ideas in detail
Flexibility	32,03	Relatively low; students lack flexibility in changing strategies
Originality	22,52	Lowest; students have difficulty generating unique ideas

From the results of the student creative thinking ability test, the fluency indicator has the highest score. This indicates that students demonstrated relatively strong fluency in generating multiple ideas. However, the

originality score is the lowest, this shows that creating unique and innovative ideas is still limited. This result is in line with the research of which shows that Indonesian students tend to be better at generating many ideas (fluency) than originality (creating original solutions) [19].

Binomial Test Results

To test whether the proportion of students who were able to solve renewable energy problems creatively was significantly different from the expected value of 50%, a binomial test was conducted. A total of 20 original questions, 8 representative questions were selected, namely 2 questions per indicator for binomial analysis. The selected questions were number 1, 5, 8, 9, 11, 15, 17 and 20. Students' answers were categorised with a score of 1 if the answer was correct and a score of 0 if the answer was incorrect. The expected proportion was set at 50%, which means it was assumed that half of the questions (i.e. 4 out of 8 questions) could be answered correctly by random students. This test aims to determine whether the proportion of students who answered correctly is significantly different from the expected value. The proportion of students' answers can be seen in Table 3 and Table 4.

Table 3. Proportion of student answers

Category	Proportion	Students
Correct Answer (>50%)	36%	39 people
Wrong Answer (≤50%)	64%	70 people

Table 4. Results of binomial test of the proportion of students' answers

		Category	N	Observed Prop.	Test Prop.	Exact Sig. (2-tailed)
Kategori Keberhasilan	Group 1	<= .5	70	.64	.50	.004
	Group 2	> .5	39	.36		
	Total		109	1.00		

Interpretation of Findings

The binomial test results in this study provide a fairly clear picture of the creative thinking ability of MTs students in South OKU to solve renewable energy questions. Based on the analysis, it was found that the proportion of students who were able to answer more than 50% of the questions correctly at 36% was significantly lower than the expected value of 50%. The results of this binomial test show that most of the students, 64%, failed to reach the expected proportional standard, although there were a number of students who showed creative thinking potential. This means that students' creative thinking skills in solving renewable energy problems still do not reach expectations. This proportion is significantly different from the expected value of 50%, with a two-sided significance value of 0.004, which is much smaller than the threshold ($\alpha = 0.05$). Based on these results, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. It can be concluded that less than half of the students are able to solve renewable energy problems creatively.

This study provides strong evidence that the creative thinking ability of MTs students in South OKU in solving renewable energy problems has not been in accordance with the assumption of the expected proportion of 50%. The distribution of students' abilities tends to lean towards the lower, there are still many students who struggle to achieve the expected level of success. This indicates that the proportion of students who are able to solve renewable energy problems creatively is significantly lower than the expected value.

This is in line with the research objective to determine whether students' ability to solve energy-related problems creatively is different from what is expected. The binomial test results indicate that students' creative thinking skills are uneven and still require more effective educational interventions. Although there were some students who showed potential in creative thinking (36% of students managed to score above 50% of the questions), their number was relatively small compared to the group of students who had not managed to reach that standard, which was 64%. Based on interviews with 15 students, this was caused by several factors, such as teacher-centred learning methods, lack of practical exploration in science learning, and students' lack of understanding of the topic of renewable energy. This is in line with research conducted by Fideli & Aliazas, which mentions that the learning method factor dominated by lectures and question exercises is the main cause of low student creativity in science learning [20].

South OKU District's diverse geography and relatively limited access to education in some areas may also have contributed to these results. Therefore, these findings emphasise the need for systematic efforts to improve students' creative thinking skills through more innovative learning approaches that are relevant to the global context.

IV. CONCLUSION

Based on the results of research and data analysis using the binomial test, it can be concluded that:

1. The overall level of students' creative thinking ability in solving renewable energy-related problems remains below the expected benchmark. Among the TTCT indicators (fluency, flexibility, originality, elaboration), the fluency indicator has the highest average value of 60.54, while the originality indicator has the lowest value of 22.52.
2. Based on the binomial test, the proportion of students who can answer more than 50% of the questions correctly is only 36%, while 64% of students are below the expected value of 50%.
3. The statistical results show that the two-sided test has a significance level of $0.004 < \alpha = 0.05$, so H_0 is rejected and H_1 is accepted. Thus, students who are able to creatively solve renewable energy problems are significantly lower than the expected value.
4. Factors that influence this low proportion include teacher-centred learning methods, lack of practical exploration in science learning, and limited student understanding of the concept of renewable energy.

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