International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 12, Issue 3, 2020

The Design of an Instrument for Identifying Students' Creativity in Solving Mathematical Problems

Atin Supriatin[a*], Zulela MS[b], Endry Boeriswati[c], Siti Annisah[d], Aeni Latifah[e], Ali Iskandar Zulkarnain[f], [a,b,c]Basic Education, Jakarta State University, Indonesia, [d]Madrasah Ibtidaiyah Teacher Education, State Islamic Institute of Palangkaraya , Indonesia, [e]Early Childhood Education Program, State Islamic Institute of Palangkaraya, Indonesia, [f]Early Childhood Education Program, State Islamic Institute of Palangkaraya, Indonesia, Email: [a*]atin.supriatin@mahasiswa.unj.ac.id,

The standard instrument identifying students' creativity in solving mathematical problems is still rarely used as a reference. One of the most important things an instrument must have is to match the objectives which will be measured and meet the validity and reliability. This research aims to illustrate the design of a valid and reliable instrument to identify students' creativity in solving mathematical problems. This type of research is descriptive research. The research object is an instrument designed by researchers. Data is obtained in the form of written statements and scores of instrument validators. The instrument assessment was conducted by three validators consisting of three lecturers. Descriptive statistics were used for data analysis. The results are acquired instruments that meet the requirements of validity and reliability to identify students' creativity in solving mathematical problems.

Key words: *Creativity, Design of instrument, Solving mathematical problems.*

Introduction

Math learning in schools not only aims at gaining knowledge but also is for creating new knowledge through problem solving. There are several reasons for the importance of problem solving in mathematics, among them being able to develop cognitive skills and improve creativity (Pehkonen, 1997). Solving mathematical problems requires creativity in discovering a wide range of solutions, strategies and inventions of unique or new

solutions/strategies (Runco, 2015; Siswono, 2010). Therefore, one of the crucial skills that need to be developed and upgraded in school is student's creativity (Jonsdottir, 2017).

Creativity is one of the main factors for one's success. Creative individuals will be more open to their thoughts on their own ideas and other people's thoughts. In addition, a creative person will be able to make breakthroughs and create new things in resolving the problems he faced. Sarooghi (2015) shows that creativity can increase innovative activity. Cropley (1999) mentions that creativity is inventive and new, while Mayesky (2009) adds that creativity is a way of thinking and acting to make something original. Creativity requires a balance between synthesis, analytics and practical ability (Sternberg and Williams, 1996). Creativity, according to Cropley (1999), is divided into two definitions. First, creativity is the production of new products regardless of their relevance and effectiveness. Secondly, creativity is the production of products that involve a familiar implementation in a new way that pays attention to its effectiveness and relevance. According to Munandar (2014), creativity is the result of interactions between individuals and their environment. From the above definition of creativity, it can be concluded that creativity is a person's ability to discover new or unique ways of solving problems that contain a new or unique outcome for themselves and unnecessarily something new for others (Demeneva et al., 2018).

When reviewed from the cognitive aspect, Torrance (1974) illustrates that the definition of creativity refers to four aspects of smoothness, flexibility, novelty (or originality), and organisation. The definition was also agreed by Kaufman (2008) and Piffer (2012) who mentioned that creativity refers to certain skills, such as fluent thinking, flexible thinking (flexibility), thinking originally (originality), and elaboration skills. Of these four aspects of creativity, novelty or originality is widely recognised as the most dominant aspect and always accompanies creativity (Cropley, 1997; Runco and Jaeger, 2012; Simonton, 2012; Corazza, 2016; Acar et al., 2017). This is because creativity is generally seen as a process related to the generation of original ideas, approaches, or actions (Shriki, 2010).

Students' creativity can be measured by exploring student work that represents the creative-thinking process and by observing the students' communication verbally or in writing (Worthington, 2006). The things communicated by the student could be related to the assignment, problem resolution, or verbal answers of the student to the teacher's question (McGregor, 2007). One way to identify students' creativity in solving problems is through testing. This test can be a series of assignments or structured questions set in a controlled or standard state so that students can demonstrate their ability to think creatively (Treffnger, 2002). According to Reys (2009), instruments that can be developed to measure students' creativity in problem solving are questions containing situations that can encourage students to acquire solutions, but they do not immediately know how to solve it. In addition, the questions are presented related to daily situations (Silver, 1997).

Instruments to measure students' creativity in solving mathematical problems must meet the following features: (1) in the form of problem solving; (2) divergent in the answer or resolution, thus bringing out the criteria flexibility, novelty, smoothness and elaboration; (3) in connection with more than one student's mathematical knowledge/concept beforehand and based on their ability levels, in this case fifth grade elementary school students. This is to elicit divergent thinking as a characteristic of creative thinking; (4) The information must be easy to understand and clear to catch the meaning, does not create a double interpretation and the composition of sentences using good and correct Indonesia language (Siswono, 2007).

The indicators of creativity in solving the mathematical problems measured in this research are as follows: 1) Fluency, which is the ability of students to produce various solutions in solving mathematical problems; 2) Flexibility, that is the ability of students in presenting various methods/strategies in solving mathematical problems; 3) Originality, which is the ability of students in generating solutions/answers to mathematical problems from the results of self-thought or relative uniqueness when compared with other students; and 4) Elaboration, which is the ability of students in describing or developing in detail the solution or the answer to mathematical problems obtained (Putra, 2019).

To find out the creativity of students in solving necessary mathematical problems, an instrument can be truly able to identify that creativity. The instrument must meet the validity and reliability as a measuring device. Validity indicates the extent to which the instrument can measure what needs to be measured, whereas reliability is a measure of equality or consistency in repeated observations of the same instrument (Kurian, 2011). The aim of this instrument is to measure students' creativity in solving math problems for elementary school students. Thus, the material aspect, the level of creativity, context and format of the instrument must be adjusted and meet the creative indicators as intended (Tejeda & Dominguez, 2019).

To find out if the instrument is designed to suit and fulfil the characteristics of the above, assessment by experts is done to determine the validity and reliability of the instrument. Thus, the purpose of this research is to understand that instruments designed to identify students' creativity in solving mathematical problems have qualified the validity and reliability as a measuring instrument.

Method

Research conducted was a descriptive study. The research attempted to describe and interpret the existence of instruments designed by researchers (Best, 1982). Research data obtained in the form of qualitative data and quantitative data. Qualitative data of verbal statements in writing from the assessment of the validator on the research instrument. Quantitative data in

the form of numbers were obtained from the scoring by the validator on the research instrument. Qualitative data and quantitative data collected were then analysed using descriptive methods. The criteria used to assess a designed instrument was the validity and reliability of the instrument.

In this research, the instrument was designed to be valid if it has been able to represent the expected characteristics that met the purpose and indicators of the students' creativity in solving mathematical problems. The validity of this research was limited to rational analysis of the validity of the contents and the construct. The validity of the content was a review of the accuracy of the materials used for elementary school students and question types diverging from the answers and ways of completion. The validity of the construction was to review the accuracy in the construction of instruments such as the obvious apparent question point; the question is easy to understand, does not create a double interpretation and measures the ability of students' creativity (smoothness, flexibility, originality and elaboration). To assess the validity of a rational analysis by asking for advice, opinion, commentary, and assessment to three people the validator/assessor (two people from the University of Negeri Jakarta and one person from the University of Palangkaraya).

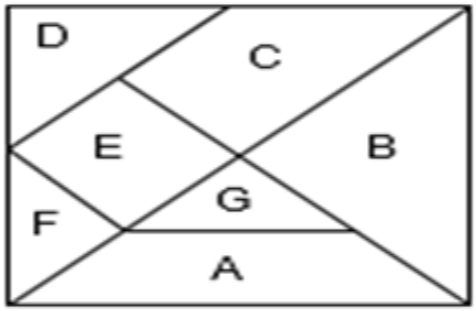
Reliability refers to the rating method, of which three validators/appraisers independently perform systematic or indirect observations and provide assessments of the instrument based on specific indicators and quantitative assessments (Azwar, 2012). The reliability level of the rating results was achieved through the average calculation of intercorrelation, which was consistent among the assessments. The average reliability calculation of three assessors' ratings was obtained through the formula given by Ebel (1951).

$$r_{xx} = \frac{S_s^2 - S_e^2}{S_s^2}$$

In this research, the procedure performed was as follows: (1) Designing an alternative instrument and sample completion to identify student's creativity; (2) Instruments in the form of problem solving in which it allows students to demonstrate an indicator of smoothness, flexibility, originality and elaboration; (3) Selected material concerning addition and subtraction of fractional different denominator. The problem in the first, second and third instruments relates to fractional equalities, addition operations, plane figures as well as comparisons. Problems in the fourth, fifth and sixth instruments relate to the plane figures, subtraction operations, fractional equalities and comparisons; and (4) All materials were ever learned by students beforehand, so that the designed instruments have been adapted to the character of the instrument to identify the creativity of students in solving mathematical problems. One example of the initial instrument design is shown in Figure 1.
Note the following picture!

Picture above is composed of 16 G units. From the picture can be obtained a summation of E + G = A with a fraction symbol $\frac{1}{8} + \frac{1}{16} = \frac{3}{16}$.
Show some of the summation results of the two parts of the image.

Figure 1. Initial Instrument Design Example



The initial draft of the instrument was validated in terms of its content and construction to three validators/judges. The validation sheet was designed by researchers, whereas the validator can provide with advice, opinions, comments or assessments on the instrument script directly. Suggestions, opinions, and comments were used by researchers as a reference for determining instrument validation results. While the assessment of the number of researchers used to determine the average reliability of the in correlation of the results of the rating of the three assessment persons. The resulting validation was used by researchers to revise the initial instruments. Furthermore, the revised instrument was the final instrument design.

Result and Discussion

Instrument Validation

The initial instrument draft was validated to 3 persons of the validator/judge. Suggestions, opinions and comments received from the three evaluators were the result of the validation of the content and the settlement of the instruments given. From the results of the analysis, the three evaluators decided that there were four instruments capable of representing the desired characteristics. Thus, the four instruments meet the criteria of validity, indicating the extent to which the instrument can measure what is to be measured (Kurian, 2011). The following were the results of the contents validation and the construction from the three validators/evaluators.

First Instrument

The first validator recommended that the first instrument has not yet demonstrated problem solving and tends to be more demanding to solve routine problems. Problem also does not

show creativity indicators. The second validator also recommended the same thing that the first instrument has namely a low level of difficulty so that it has not been able to stimulus the creativity of students. In addition, alternatives to solving questions are less precise and the commands in question are not explicitly stated. The third validator recommended that the first instrument needs revision. The revision was related to the creativity component that needs to consider students with specific learning disability and diction issues.

Second Instrument

The first validator recommended that the second instrument be worth using without revisions. While the second validator recommended that the second instrument was worth use but with revision. Such revision was by fixing the images contained in the instrument so that the problem meets the criteria of troubleshooting and the commands in question must be explicitly stated. The third validator recommended that the second instrument deserves to use but with repairs. Such revision is related to the component of creativity that is to consider students with Discalculia and dyslexia disorders. In addition, on the problem solving components need to consider students with specific learning disability and diction issues.

Third Instrument

The first validator recommended that the third instrument be worth use with revisions. These revisions include changing the number of denominators with unique numbers. In addition, on the solution alternatives do not need to use images. The second validator recommended that the third instrument be used without revisions. The third validator recommended that the third instrument can be used but with revisions. Such revision was related to the component of creativity and problem solving namely need to consider students with specific learning disability and word selection must be adjusted to the student's age.

Fourth Instrument

All validators recommended that the fourth instrument was suitable for use with revisions. The suggestion from the first validator was to consider the originality criteria in the creativity component. The second validator suggested that alternative solutions be adjusted to the age level of elementary school, while the third validator suggests considering students with specific learning disabilities and diction issues.

Fifth Instrument

The first validator recommended that the fifth instrument was appropriate to be used without revision, whereas the second validator recommended that the fifth instrument was suitable for

use with revision. The revision lies in the grammar that needs to be refined. The third validator recommended that the third instrument was feasible to use but with revisions. These revisions are related to the components of creativity and problem solving, namely the need to consider students with specific learning disability and the need for the use of appropriate diction.

Sixth Instrument

The first and second validators recommended that the sixth instrument have not yet come up with indicators of creativity, especially flexibility, and do not include criteria about problem solving and the use of commands in questions not explicitly stated. The third validator recommended that the sixth instrument can be used but with revisions. These revisions are related to the components of creativity and problem solving, namely the need to consider students with specific learning disability and the choice of words must be adjusted to the age of the student.

Based on the results of the validation of the three validators, the first and sixth instruments have not been able to represent the desired characteristics. This does not meet the validity criteria which is able to measure what is to be measured (Kurian, 2011). In the aspect of content validity, the results of the rational analysis of the three validators on the two instruments conclude that the problem cannot be categorised into the form of problem solving because the problem can be solved directly, so it does not require deep thought. This is different from the view of Reys (2009) that problem solving problems are problems that are able to encourage students to obtain solutions but do not immediately know how to solve them. This situation was intended so that students are able to think deeply with the knowledge they have. In addition, problem solving problems can encourage students to be creative in getting diverse solutions on their own thinking. Another thing that makes this problem cannot be categorised in the form of problem solving that only involves one mathematical concept. This situation was not in accordance with the expected indicators that the questions should be related to more than one student's prior knowledge /mathematical concepts (Siswono, 2007).

Reviewing from the construct validity, the results of the rational analysis of the three validators on the second and sixth instruments concluded that the two questions had weaknesses on the diction problem. In the command sentence or operational word that measures creativity in both problems was not stated explicitly. This situation will cause misunderstanding of students in interpreting the commands in the problem. As a result, the expected creativity indicator was not achieved.

The results of the rational analysis of the three validators for the second, third, fourth and fifth instruments stated that the four instruments were considered capable of representing the expected characteristics by making some revisions. In the aspect of content validation, revisions were made to the image aspect. There were enhanced images, there were pictures that need to be removed and there are numbers that need to be replaced. In the aspect of construct validation, revisions were made to the diction to be adjusted to the age of the students, the structure of the language to be easily understood and to improve the sentence sentences, to encourage students to make original answers.

The results of the rational analysis above were followed up by revising four instruments which were stated to be able to represent the characteristics expected from the content and construct aspects. The instruments that have not been able to represent the expected characteristics were not used to identify the creativity of solving mathematical problems. The revisions made to the initial draft instrument produced the final instrument, which consisted of 4 instruments. Thus, the instrument has been able to represent the desired characteristics. Therefore, the four instruments can be stated to have fulfilled the validity of the content and construct aspects so that they can be used to identify students' creativity in solving mathematical problems.

Instrument Reliability

To determine the reliability of the third assessment of the validator, the average in correlation calculation is performed, which is the consistency between the appraisers through the rating result. The assessment results are listed in Table 1.

Table 1: Rating results of instruments

NO.	**Validator**	**Question Number**						**∑i**	**∑T²**
		1	**2**	**3**	**4**	**5**	**6**		
1	Validator 1	2	5	5	5	5	2	24	576
2	Validator 2	2	4	5	3	3	2	19	361
3	Validator 3	4	5	4	5	5	4	27	729
∑R		8	14	14	13	13	8	70	1666
∑R²		64	196	196	169	169	64	858	

Based on the results of the calculations, obtained average inter-correlation of the rating of the three evaluators amounted to 0.994. These results show that the average inter-correlation of the rating result has the coefficient of consistency above the minimum. As said by Wells and Wollack (2003) that standard tests of high stakes and professionally arranged should have a minimum internal consistency coefficient of 0.90. This indicates that the rating results of three people in the assessment have high consistency.

The conclusion of the whole instrument design process resulted in a valid and reliable instrument model to identify students' creativity in solving mathematical problems.

A tank is fully loaded with water. The father took the water from the tank to fill the bath with drums and buckets. A drum can take 1/2 parts of water in a tank, while a bucket can take 1/8 parts of water in the tank. If the current tank remains 1/4 parts of water, how much water has been taken by father. How many drums and/or buckets can a father use to retrieve the water? Use images to illustrate your answer and give it a detail.

From the example of the above instruments there are criteria to identify the creativity of students in solving the problem of mathematics is as follows: (1) Instrument form of problem solving, namely questions challenge the mind, the form of problems is non-routine and allows a variation of the answer/strategy, so that the indicator of creativity will be systematically demonstrated by the students; (2) The material has already been studied or already known to students beforehand either from the school or his own experience; (3) The question involves some mathematical material or concepts; (4) The grammar structure needs to be adjusted to the student's age for easy understanding of meaning and does not cause double interpretation; and (5) the selection of proper diction and the difficulty of the problem is to consider students with learning difficulties.

Conclusion

Based on the results of the analysis, researchers found an instrument model to identify the creativity of elementary school students in solving valid and reliable mathematical problems. The thing to note in designing the instrument is to fulfil the criteria of the contents and the construction. The content aspect shows that the material on the instrument has already been learned by students before either school or his own experience, and the question in the instrument needs to involve some mathematical material or concepts, other than that the instrument theme can be problem solving. The construction aspect suggests that the form of the instrument can be questions that challenge deep mind, and the form of problem is non-routine and using the operational word or the command sentence that stimulus the emergence of the variation of answers/strategy, so that the indicator of creativity will be systematically demonstrated by students. The use of grammar structures needs to be adjusted to the age of students for easy understanding of the meaning and does not cause double interpretation. In addition, the selection of appropriate diction and difficulty level needs to consider students with learning difficulties.

Realising that this research is limited to rational analysis of content and contraction validation as well as limited to the reliability of the rating results, subsequent research can be expanded with a more profound type of validity and reliability empirically in class.

Acknowledgements

The author would like to say thank you for all the validators that have participated in data collection. The author also wants to thank the lecturer who has given the instruction and input in conducting this research.

Disclosure Statement

No potential conflict of interest was reported by the authors.

REFERENCES

Acar, S., Burnett, C., & Cabra, J. F. (2017). Ingredients of Creativity: Originality and More. Creativity Research Journal, 29(2), 133-144. https://doi.org/10.1080/10400419.2017.1302776

Azwar, S. (2012). Reliabititas dan Validitas. Yogyakarta: Pustaka Pelajar.

Best, J. W. (1982). Metodologi Penelitian Pendidikan. Terjemahan oleh Sanapiah Faisal, Surabaya: Usaha Nasional.

Corazza, G. E. (2016). Potential Originality and Effectiveness: The Dynamic Definition of Creativity. Creativity Research Journal, 28(3), 258–267. https://doi.org/10.1080/10400419.2016.1195627

Cropley, A. J. (1997). More Ways Than One: Fostering Creativity. USA: Ablex Publishing Corporation.

Cropley, A. J. (1999). Definitions of Creativity Encyclopedia of Creativity. Ed. Runco, M. A., & Pritzker, S. R. USA: Academic Press.

Demeneva, N. N., Gutsu, E. G., Kochetova, E. V., Mayasova, T. V., & Kolesova, O. V. (2018). Implementation of competency approach in teaching mathematics to primary school children. Edición Especial, 34(15).

Ebel, R. L. (1951). Estimation of The Reliability of Ratings. Psychometrika, 16(4), 407–424.

Jonsdottir, S. R. (2017). Narratives of Creativity: How Eight Teachers on Four School Levels Integrate Creativity into Teaching and Learning. Thinking Skills and Creativity, 24, 127-139.

Kaufman, J. C., Plucker, J. A., & Baer, J. (2008). Essential of Creativity Assessment. Canada: John Wiley & Sons Inc.

Kurian, G. T. (2011). The Encyclopedia of Political Science: Reliability and Validity Assessment. Washington: CQ Press.

Mayesky, M. (2009). Creative Activities for Young Children. USA: Delmar Cengage Learning.

McGregor, D. (2007). Developing Thinking, Developing Learning. England: Open University Press.

Munandar, U. (2014). Pengembangan Kreativitas Anak Berbakat. Jakarta: PT Rineka Cipta.

Pehkonen, E. (1997). Fostering of Mathematical Creativity: The State-of-Art in Mathematical Creativity. ZDM Mathematics Education, 29(3), 63-67.

Piffer, D. (2012). Can Creativity Be Measured? An Attempt to Clarify the Notion of Creativity and General Directions for Future Research. Thinking Skills and Creativity, 7(3), 258-264.

Putra, Z. H. (2019). Danish Pre-service Teachers' Mathematical and Didactical Knowledge of Operations with Rational Numbers. International Electronic Journal of Mathematics Education, 14(3), 619-632.

Reys, R., et., al. (2009). Helping Children Learn Mathematics. USA: John Wiley & Sons, Inc.

Runco, M. A. & Jaeger, G. J. (2012). The Standard Definition of Creativity. Creativity Research Journal, 24(1), 92–96.

Runco, M. A. (2015). Meta-Creativity: Being Creative About Creativity. Creativity Research Journal, 27(3), 295-298.

Sarooghi, H., Libaers, D., & Burkemper, A. (2015). Examining the Relationship Between Creativity and Innovation: A Meta-Analysis of Organisational, Cultural, and Environmental Factors. Journal of Business Venturing, 30(5), 714-731.

Shriki, A. (2010). Working Like Real Mathematicians: Developing Prospective Teachers' Awareness of Mathematical Creativity Through Generating New Concepts. Educational Studies in Mathematics, 73(2), 159-179.

Silver, E. A. (1997). Fostering Creativity Through Instruction Rich in Mathematical Problem Solving and Problem Posing. ZDM Mathematics Education, 29(3), 75-80.

Simonton, D. K. (2012). Taking the U.S. Patent Office Criteria Seriously: A Quantitative Three-Criterion Creativity Definition and Its Implications. Creativity Research Journal, 24(2-3), 97-106.

Siswono, T. E. (2007). Desain Tugas untuk Mengidentifikasi Kemampuan Berpikir Kreatif Siswa dalam Matematika. https://tatagyes.files.wordpress.com/2007/10/tatag_jurnal_unej.pdf

Siswono, T. E. (2010). Leveling Students' Creative Thinking in Solving and Posing Mathematical Problem Journal on Mathematics Education, 1(1), 17-40.

Sternberg, R. J. & Williams, W. M. (1996). How to Develop Student Creativity. Virginia: Association for Supervision and Curriculum Development.

Torrance, E. P. (1974). The Torrance Tests of Creative Thinking: Technical-Norms Manual. Bensenville, IL: Scholastic Testing Services.

Treffnger, D. J. (2002). Assessing Creativity: A Guide for Educators. Florida: The National Research Center on the Gifted and Talented.

Worthington, M. (2006). Creativity Meets Mathematics. Practical Pre-school, 3, 1-8.

Tejeda, S., & Dominguez, A. (2019). Influence of Interactions in the Collaborative Solving of a Velocity Problem. *International Electronic Journal of Mathematics Education, 14*(1), 91-108. https://doi.org/10.12973/iejme/3979