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Research Article

Development of minimum competency assessment (AKM) instruments to measure the numeration ability of seventh grade of junior high school students

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ABSTRACT

Numeration is one of the competencies measured in AKM. Numerical ability in AKM is the ability to solve mathematical problems using various numbers and symbols in the context of numbers, measurements and geometry, data and uncertainty, and algebra that uses cognitive processes of knowing, applying, and reasoning in personal, socio-cultural, and scientific contexts. This research is a type of development research that aims to produce a product in the form of an expanded multiple-choice test instrument to measure the numeracy skills of seventh-grade junior high school students. The development model used is the four-D Model by Thiagarajan which is modified into three stages (define, design, and develop). The scoring technique uses polytomies and involves 70 students as test subjects for the instrument. The results showed that (1) the characteristics of the AKM instrument developed in terms of context and cognitive level were close to the estimated percentage and covered four domains with their respective minimum competencies, (2) item validity values ranged from 0.274 to 0.743, (3) the instrument reliability coefficient is 0.88, (4) the level of difficulty is 8% easy, 80% is moderate and 12% is difficult, (5) the discrepancy index is between 0.43 to 0.78, (6) 92% questions have good distractor effectiveness.

Keywords: instrument; AKM; numeration

1. INTRODUCTION

The education system in Indonesia continues to change, one of which is the abolition of the National Examination (UN) as a graduation standard for elementary to high school education. The Indonesian Minister of Education and Culture (Mendikbud) in 2019 Nadiem Anwar Makarim changed to the policy of abolishing the National Examination (UN) and w replaced with a National Assessment that consists of three parts namely Minimum Competency Assessment (AKM), Character Survey; and Environmental Survey in 2021 (Pendidikan, M., 2019). A reform of the National Examination which was replaced with AKM is needed to be able to encourage an increase in the quality of learning in Indonesia (Winata, 2021). The meaning of this minimum to show the size that students have can be seen from reading literacy and numeracy which are competencies that at least must be possessed for someone to function productively in life (Cahyanovianty, 2021). AKM is an evaluator and a fundamental competency needed by all students to be able to develop their own capacity and participate positively in society. AKM is not a benchmark for student graduation and is not a requirement for selection for the next level of education. AKM does not focus on student test results, but the test results are used as guidelines or reflections to improve the quality of school learning. The implementation of AKM is adaptive, which means that each student works on questions according to his abilities (Maryuliana, 2016). AKM measures the basic competencies that all students need to learn regardless of their specialization. Therefore, all students will get questions that can measure the same competency. The AKM set by the government is one part of the government's targets to prepare students to face the 21st century, namely having critical thinking skills, creativity, communication skills and collaboratively (Andiani, 2020).

One of the basic competencies measured by AKM is mathematical literacy, known as numeracy. Numerical ability can be interpreted as a person ability to formulate, apply, and interpret mathematics in various contexts, including the ability to reason systematically, and use concepts, procedures and facts to illustrate, explain or predict phenomena/events (Ekowati et al., 2019). One thing that refers to an individual's ability to formulate, use and interpret mathematics in both contexts (Wulandari & Azka, 2018). By implying that the meaning of numeracy is not only being able to carry out procedures in solving mathematical problems but also utilizing mathematics into everyday life, as in literate which means (literacy) towards mathematics (Aningsih, 2018). According to Cockroft in Goos, at all (2011), numeracy ability is a skill in solving practical problems using numbers. Numerical ability is the ability to apply number concepts, arithmetic operations skills and the ability to explain information something around us (Han, et al., 2017).

Based on the several definitions of numeracy ability above, briefly the numeracy ability referred to in AKM is the ability to solve mathematical problems by using various kinds of numbers and symbols related to basic mathematics to solve practical problems in various contents by using cognitive processes in various contexts with the purpose to help students recognize the role of mathematics in real life so that they can make the necessary evaluations and decisions and become responsible human beings who are able to reason/think logically. One of the benchmarks for education in Indonesia is the numeracy ability of the nation children. However, the Indonesian students still have low based on the Evaluator an TIMSS (Trends International Mathematics and Science Study) and PISA (Program for International Student Assessment). In the 2015 TIMSS activities, Indonesia obtained a score of 397 related to the mathematical aspect, while the average TIMSS global score is around a score of 500 (TIMSS, 2019). This information shows that the achievement of Indonesian students, especially students numeracy abilities, is still far from being satisfactory. It is also in line with the results of PISA. PISA is designed to collect information through three yearly rotational assessments to determine students' abilities in literacy reading, mathematics, and science. Since 2000, PISA has conducted a survey and the latest score in 2018 Indonesia that was ranked 72 out of 79 countries participating in the test. The test results showed that the average score of Indonesian students was 371 in reading, 379 in mathematics, and 396 in science. This score is lower than the average score of the OECD (The Organization for Economic Cooperation and Development), which is 487 for reading ability. and 489 for math and science skills (OECD, 2019).

The data showed the low numeracy skills of children in Indonesia, even though if it is linked in real life, a skilled workforce and achievement of basic competencies in terms of numeracy abilities have an interrelated relationship. There is little possibility of creating a skilled and competitive workforce in the future, if students do not master basic competencies in numeracy from the start (Kemdikbud, 2019). Considering that, one aspect of the evaluator in AKM requires numeracy skills, therefore, numeracy skills must be improved by optimizing the learning process and providing exercises for numeracy skills. Based on the interview results of several junior high school mathematics teachers, numeracy AKM questions are still rarely given considering that the Computer-Based National Assessment (ANBK) will only be officially held in 2021, so the current availability of AKM instruments is necessary to get a figure of student numeracy abilities from an early age. Currently there are not many appropriate instruments available to measure the desired numeracy ability, so it is necessary to develop more AKM instruments that can be used to measure student numeracy abilities. Furthermore, this AKM instrument also has special characteristics that distinguish it from other evaluation questions so that it is feasible to develop. Therefore, it is necessary to develop an AKM instrument that can measure student numeracy abilities, especially at the junior high school level, because it will be very useful for their future.

2. RESEARCH METHOD

This study is the development research to develop a product, namely in the form of an AKM instrument in the form of an expanded multiple-choice test that is effectively used to measure the numeracy abilities of class VII students. The development model used in developing this product is the four-D Models by Thiagarajan, 1974 (in Trianto, 2007:56) that is modified into three stages, namely defining, designing, developing. This study used four data collection methods namely interviews, validation sheets, documentation, and tests. The scoring technique used polyotomy and involves 70 students as test subjects for the instrument. The data in this study were obtained from the results of a questionnaire filled out by the validator to test the content validity of the instrument developed using the Gregory formula, as well as the results of student acquisition scores after product trials used in the calculation to find the validity of the Number using the product moment correlation coefficient formula, reliability test using the Alpha-Cronbach formula, the hardness level of Number that was carried out by considering the number of respondents who answered the Number correctly, the discriminating power of Number using the Ferguson formula, and the effectiveness of the distractor by calculating the test takers who choose each alternative for each Number of the questions given (Candiasa, 2011).

3. RESULTS AND DISCUSSION

This study involved two experts as instrument validators and a limited trial of the instrument that was carried out at Singaraja 1 Public Middle School which consisted of 70 class VII students for the 2021/2022 academic year. The instrument developed was in the form of 25 Numbers of multiple choice questions expanded. The data can be seen in **Table 1**.

Table 1. Results of Gregory Content Validity Test

		Evaluator 1	
		Less relevant (Score 1-2)	Very relevant (Score 3-4)
Evaluator 2	Less relevant (Score 1-2)	0	25
	Very relevant (Score 3-4)	0	25

Based on the **Table 1**, it is found that all experts stated that the question items from numbers 1 to 25 were very relevant according to the grid made. The results of calculations using the Gregory formula obtained content validity values = $\frac{25}{25} = 1$, It means that content validation is very high according to Gregory content validity criteria.

Table 2. Results of Instrument Item Validity Test

Number	Product Moment Correlation (r_{xy})	Part-Whole Correlation (r_{bt})	r_{tabel} ($\alpha = 0{,}05$)	Descriptions
1	0. 432	0. 388	0. 235	Valid
2	0. 694	0. 666	0. 235	Valid
3	0. 689	0. 658	0. 235	Valid
4	0. 688	0. 659	0. 235	Valid
5	0. 416	0. 361	0. 235	Valid
6	0. 506	0. 462	0. 235	Valid
7	0. 239	0. 274	0. 235	Valid
8	0. 340	0. 291	0. 235	Valid
9	0. 646	0. 616	0. 235	Valid
10	0. 539	0. 497	0. 235	Valid
11	0. 420	0. 373	0. 235	Valid
12	0. 703	0. 681	0. 235	Valid
13	0. 763	0. 743	0. 235	Valid
14	0. 707	0. 682	0. 235	Valid
15	0. 761	0. 733	0. 235	Valid
16	0. 705	0. 674	0. 235	Valid
17	0. 599	0. 562	0. 235	Valid
18	0. 390	0. 346	0. 235	Valid
19	0. 471	0. 452	0. 235	Valid
20	0. 504	0. 462	0. 235	Valid
21	0. 622	0. 587	0. 235	Valid
22	0. 643	0. 609	0. 235	Valid
23	0. 660	0. 627	0. 235	Valid
24	0. 545	0. 512	0. 235	Valid
25	0. 260	0. 299	0. 235	Valid

Based on the **Table 2**, it showed that $r_{hitung} > r_{tabel}$ p, on all Number questions so that all Numbers were declared valid. Based on the results of this validity test, the number of valid questions was analyzed to determine the reliability coefficient, the differential power of the Number, the level of hardness of the Number, and the effectiveness of the detractor. In calculating the reliability of the test using the Ministep software, data were obtained as shown in the Figure Summary Statistics results below.

Figure 1. The Summary of Person Reliability Statistics

```
     SUMMARY OF 70 MEASURED Person
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT         OUTFIT    |
|          SCORE      COUNT     MEASURE   S.E.      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN      53.9       24.8      -2.32     .27      1.08    -.7   1.09    -.9 |
| P.SD      12.0        1.9       1.06     .03      1.24    3.1   1.50    3.0 |
| S.SD      12.1        1.9       1.07     .03      1.25    3.1   1.51    3.0 |
| MAX.      88.0       25.0        .94     .42      6.56    8.1   9.90    6.7 |
| MIN.      10.0        9.0      -7.49     .24       .11   -5.3    .10   -4.7 |
|-----------------------------------------------------------------------------|
| REAL RMSE     .34 TRUE SD     1.01  SEPARATION  2.94  Person RELIABILITY  .90 |
|MODEL RMSE     .27 TRUE SD     1.03  SEPARATION  3.75  Person RELIABILITY  .93 |
| S.E. OF Person MEAN = .13                                                    |
-------------------------------------------------------------------------------
Person RAW SCORE-TO-MEASURE CORRELATION = .86
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .89  SEM = 3.97
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Figure 2. The Summary of Item Reliability Statistics

```
    SUMMARY OF 25 MEASURED Item
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE     COUNT     MEASURE   S.E.       MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN     153.0      70.4         .00    .16       1.04    -.1   1.01    -.2 |
| P.SD      42.2        .5        1.22    .03        .51    2.6    .44    2.3 |
| S.SD      43.0        .5        1.25    .03        .52    2.6    .45    2.4 |
| MAX.     255.0      71.0        3.00    .22       2.71    6.6   1.92    4.0 |
| MIN.      67.0      70.0       -2.22    .14        .23   -6.3    .22   -5.8 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .18 TRUE SD    1.21  SEPARATION  6.55  Item   RELIABILITY  .98 |
|MODEL RMSE    .17 TRUE SD    1.21  SEPARATION  7.31  Item   RELIABILITY  .98 |
| S.E. OF Item MEAN = .25                                                     |
-------------------------------------------------------------------------------
Item RAW SCORE-TO-MEASURE CORRELATION = -.98
Global statistics: please see Table 44.
UMEAN=.0000 USCALE=1.0000
```

Based on the figures above, it can be seen that the Person Reliability value was 0.90; and Item Reliability value was 0.98. Based on the results of calculating the differential power of Number using the Ferguson formula with manual calculations using the help of Microsoft Excel, the following results are obtained.

Table 3. The Results of Number Different Power Test

Number	Power Distance Index	Number	Power Distance Index	Number	Power Distance Index	Number	Power Distance Index	Number	Power Distance Index
1	0.43	6	0.74	11	0.65	16	0.43	21	0.45
2	0.76	7	0.78	12	0.57	17	0.51	22	0.52
3	0.65	8	0.57	13	0.64	18	0.54	23	0.54
4	0.63	9	0.64	14	0.62	19	0.43	24	0.47
5	0.72	10	0.64	15	0.49	20	0.45	25	0.69

Based on the table above, Power Distance Index was $\geq 0,40$, it means that the discriminating power of Numbers was classified as very good according to the criteria for discriminating power in Number questions from Ebel.

Table 4. The Results of Difficulty Level Test

Number	Difficulty Index (I)	Description	Number	Difficulty Index (I)	Description
1	0. 82	Easy	14	0. 67	medium
2	0. 66	Medium	15	0. 53	medium
3	0. 70	Medium	16	0. 52	medium
4	0. 60	Medium	17	0. 52	medium
5	0. 66	Medium	18	0. 43	medium
6	0. 67	Medium	19	0. 22	hard
7	0. 65	Medium	20	0. 32	hard
8	0. 32	Medium	21	0. 52	medium
9	0. 73	Easy	22	0. 55	medium
10	0. 60	Medium	23	0. 53	medium
11	0. 49	Medium	24	0. 29	hard
12	0. 63	Medium	25	0. 51	medium
13	0. 64	Medium			

There are numbers of the question with the hardness index in the range of 3 Numbers with hardness range of $0,00 \leq I \leq 0,30$ It means the difficulty level of the question was classified as hard, 20 questions with hardness index in the value range $0,31 \leq I \leq 0,70$ It means the difficulty level of the question was medium, and 2 questions had a hardness index in the range of values $0,71 \leq I \leq 1,00$ with easy hardness level.

Table 5. Results of Testing the Effectiveness of the Deceiver

Number	Choice				Key	Description
	A	B	C	D		
1	4	61	0	4	B	Detractor C is not good
2	52	4	8	5	A	All deterctors are good
3	5	4	52	6	C	All deterctors are good
4	4	5	4	54	D	All deterctors are good
5	4	8	6	49	D	All deterctors are good
6	48	13	4	4	A	All deterctors are good
7	5	54	4	6	B	All deterctors are good
8	6	5	8	46	D	All deterctors are good
9	1	5	1	60	D	Detractor A and C are not good
10	7	54	4	4	B	All deterctors are good
11	4	51	8	5	B	All deterctors are good
12	56	4	5	4	A	All deterctors are good
13	5	5	52	5	C	All deterctors are good
14	4	5	4	54	D	All deterctors are good
15	56	4	4	5	A	All deterctors are good
16	4	6	51	4	C	All deterctors are good
17	4	4	7	50	D	All deterctors are good
18	8	49	4	5	B	All deterctors are good
19	53	8	1	4	C	All deterctors are good
20	7	52	4	4	A	All deterctors are good
21	4	55	5	4	B	All deterctors are good
22	53	6	4	4	A	All deterctors are good
23	53	4	5	5	A	All deterctors are good
24	5	50	4	9	A	All deterctors are good
25	6	5	53	4	C	All deterctors are good

Based on the **Table 5**, it is found that the 23 Number questions had a good distractor, the two number questions had a bad distractor. In the AKM instrument developed, there were 14 question numbers or 56% that were included in the personal context, 7 question numbers or 28% in the socio-cultural context, and 4 question numbers or 16% in the scientific context. When compared with the estimated percentage distribution of questions based on the context in the development of the AKM Numeral SMP level, namely 40% personal, 40% socio-cultural, and 20% scientific, the AKM instrument developed was close to the estimated percentage. The cognitive level for the AKM numeracy questions was divided into three levels, namely knowing (understanding), applying (application) and reasoning (reasoning). In the AKM instrument developed there were 6 Number of questions or 24% at the knowing cognitive level (understanding), 12 Numbers of questions or 48% at the applying cognitive level, and 7 Numbers of questions or 28% at the cognitive level of reasoning (reasoning). When compared with the estimated percentage distribution of questions based on cognitive level in the development of the AKM Numeral Junior High School level, namely knowing 25%, applying 50%, and reasoning 25%, the AKM instrument developed was close to the estimated percentage. The content domains in the numerical AKM instrument developed are Numbers, Geometry and Measurement, Algebra, and Data and Uncertainty. In each domai, there is a minimum range of competencies expected at each grade level. The minimum competency coverage of each domain used in the development of this AKM instrument is as follows.

Table 6. Minimum Competency Coverage for Each Domain in Developed AKM Instrument

Domain	Subdomain	Minimum Competency
Number	Representation	1. Understand integers especially negative integers 2. State a decimal number with two decimal places and a percentage in fractional form and vice versa. 3. Know the position of decimal numbers with two decimal places on the number line and the position of integers including negative integers.

	Sequence Properties	Sort several numbers expressed in different forms
	Operation	Calculate the results of addition/subtraction/multiplication/division of fractions or decimal numbers, including calculating the square and cubic of a decimal number with one decimal place. As well as Operations on integers including negative integers
Geometry and Measurement	Figure and Geometry	1.Calculate the area of a flat shape (composite) 2. Understand the properties of plane shapes and the relationship between plane shapes and be able to use the Pythagorean Theorem
Algebra	Equality and Inequality	1. Solve one-variable and two-variable linear equations in everyday problems 2. Solve one-variable linear inequalities
	Ratio and Proportion	1.Use a ratio/scale to determine unknown values/numbers 2. Solve social arithmetic problems related to ratios/percentages
Data and Uncertainty	Data and the Representation	1. Reading picking information from) data presented in the form of tables, bar charts, and pie charts (including the method of collecting data and how it is presented)

In the AKM instrument developed, there were 8 questions or 32% of the number domain, 5 questions or 20% of the geometry and measurement domain, 10 questions or 40% of the algebraic domain, and 2 questions or 8% of the data and uncertainty domain. The proportion of the number of questions in this development adjusts to the number of existing minimum competencies and the density of material at 7th of junior high school level.

4. CONCLUSION

Based on the description above, it can be concluded that :

1. The characteristics of the Numerical AKM Instrument developed are reviewed both in terms of context and cognitive level, the questions are close to the estimated percentage of Numerical AKM questions, and in terms of domain content, they cover four domains with the respective minimum competencies so that they are in accordance with the guidelines for developing AKM Numeracy instruments.
2. The quality of the Numeration AKM instrument developed in terms of (a) the validity of the Number, (b) the reliability of the instrument, (c) the hardness level of the item, (d) the differentiability of the Number, and (e) the effectiveness of the detractor in general with good quality according to their respective criteria such as :
   a) using the part-whole correlation technique, the validity value of the Number ranges from 0.274 to 0.743, it means that all Numbers meet the validity standard with the good quality.
   b) The reliability coefficient of the instrument is 0.88, it means that the reliability of the test is in the high category. The Person Reliability value is 0.90, it means that the consistency of the students' answers is classified as special. The Item Reliability value is 0.98, it means that the quality of the Number questions on the AKM instrument for which the reliability aspect developed is special.
   c) The power distance index of the test equipment shows the > 0.4 a value that ranges from 0.43 to 0.78 with an average power distance index of 0.58, it means that the differential power of the number is classified as very good
   d) of the 25 Numbers of questions, there are 2 Numbers of questions or 8% categorized as easy questions, 20 Numbers of questions or 80% categorized as medium questions and 3 other questions or 12% are categorized to the category of hard questions.
   e) 92% of all the questions developed have good distractor effectiveness.

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AUTHOR'S CONTRIBUTIONS

All authors discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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