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Instrument Design to Measure the Critical Thinking Skill of Students that Participate in Chemistry National Science Olympiad

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Abstract

Critical thinking definition is reasonably and reflectively thinking focused on what to believe or do. In today settings, the ability to think critically is very important, due to the increasing amount of information that must be processed before deciding something. National Science Olympiad is one of the vessels to increase this important skill in our students. Unfortunately, the OSN questions were not designed for measuring this skill. The aim of this research was to design an instrument that measure the critical thinking skill of the OSN participants. This was an R & D type of research, that was done following Four-D method, consists of define, design, development, and dissemination steps. The criteria for a good instrument are validity, reliability, discrimination power, and difficulty level must be sufficient. The result of the research shows that the instrument is valid (89,9% response from experts); reliable (KR-20 is 0,830); with sufficient average of discrimination power (DP is 0,378); and difficulty level (TK is 0,613).

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INTRODUCTION

National Science Olympiad (from here onward, OSN) is the annual competition of mathematics and science organizes by the Ministry of Education and Culture (MOEC), it is done for three levels: primary (SD), secondary (SMP), and high school (SMA) students. OSN is arguably the highest rank and the most prestigious science competition in the country for primary up to high school students.

The first OSN was held in 2002 in Yogyakarta, and in the years that followed it was consistently done without a single break up to now. This year, 2018, is the 17th OSN competition held by Ministry of Education and Culture, and it is done in Padang, on 2-8 July 2018. The Ministry of Education and Culture stated that the goals of the OSN are to develop the student's characters such as honesty, discipline, sportive, perseverance, creativity, toughness, and patriotism; it also acts as a vessel to motivate and facilitate students' potentials and interests in the field of science. The last goal is to select the best students that will represent Indonesia in international science competitions and olympiads (Kemdikbud, 2018).

National Science Olympiad is done in several stages. The first stage is school selection. Here, each school would select the students that will represent the school in the City/Regency level selection, which is the second level selection. Each school usually allowed to send up to 3 students to join City/Regency selection. In the City/Regency level, student would do one round, theoretical only, of examination (multiple choice and essay questions are asked). The next level of selection was the Provincial selection. In this level, the best students from cities and regencies in a province would compete, the type of question were the same with the City/Regency level examination, theoretical without practical exam. The students that passed the provincial examination would be invited to National Science Olympiad, usually around 90 students were invited to compete at national level. In the national level, the students would do both theoretical and practical examination, usually in the course of 2 days. The OSN usually done in 6 to 7 days, the days that are not used for examination was filled with other activities such as excursion to tourism spots in the host province.

The Indonesian National Science Olympiad is a fierce competition. In 2016, there were 328.820 students competing in the City/Regency level (Media Indonesia, 2016). From that many students, 774 students were invited to compete at national level. There were 270 medalists for 9 subjects in the national level or 0,08% of the total students that compete on City/Regency level (Kemdikbud, 2016).

Since the first OSN, there are only 2 provinces that have become overall champions, those provinces are D.K.I. Jakarta and Central Java. Central Java championed the OSN 10 times, and D.K.I. Jakarta 6 times. The list of the overall champions of OSN is presented in Table 1.

From this set of data, it can be inferred that these 2 provinces are preparing their students really well for the National Science Olympiad, they are so dominant in the course of the competition that they leave all other provinces behind.

The rules and regulations of the OSN is determined by the MOEC. Every year MOEC release OSN guidebook for schools and students, in this book the rules and regulations for OSN is detailed. The rules and regulation of OSN does not change much from year to year.

One of the aims of the rules and regulations of OSN is to promote educational equity. That is why some rules such as the limitation of students that can compete in the OSN and the ineligibility of the previous OSN medallists are in place. With this kind of rules MOEC try to make OSN as an event that give as much as possible chance for students who are willing to join it.

Ministry of Education and Culture also release the syllabus for all branches of OSN. In chemistry OSN, the syllabus is based on the International Chemistry Olympiad (IChO) syllabus. This syllabus also did not change much over the years. The last major changes to the

content of the syllabus happened 10 years ago on 2008. The questions that are used in the OSN selection process always based on the syllabus that is released by MOEC. All questions from the city/regency level up to national level are prepared by a team of judges that consists of university professors or lecturers. The questions prepared for the OSN also take into consideration the topics covered by that year preparatory problems announced by the IChO committee of that year.

Table 1. The Overall Champions of OSN from 2002-2018

Year	Overall Champion	Year	Overall Champion
2002	Jawa Tengah	2011	Jawa Tengah
2003	Jawa Tengah	2012	Jawa Tengah
2004	D.K.I. Jakarta	2013	Jawa Tengah
2005	D.K.I. Jakarta	2014	D.K.I. Jakarta
2006	Jawa Tengah	2015	Jawa Tengah
2007	Jawa Tengah	2016	Jawa Tengah
2008	Jawa Tengah	2017	D.K.I. Jakarta
2009	D.K.I. Jakarta	2018	D.K.I. Jakarta
2010	D.K.I. Jakarta		

There are 3 groups of topics in the chemistry OSN syllabus. The first groups of topics are most of the topics that is covered by the national curriculum; all participants are expected to have already learned these topics at their schools. The second groups are the topics that may or may not be covered by national curriculum, but must be learned by the participants. The last groups of topics are the topics that are not covered by the national curriculum, and the participants only expected to have learned all these topics before they compete in international level.

During the chemistry National Science Olympiad competition the participants from all over Indonesia solved two types of problems, theoretical and practical. Their works then evaluated by a team of judges, and the winner will be announced on the closing night of the OSN. Five gold medals, 10 silver medals, and 15 bronze medals will be distributed to all winners. Along with the medals, they will also accept certificates of achievement and also some money from MOEC.

The chemistry National Science Olympiad questions, share the same characteristic with the International Chemistry Olympiad questions. Most of the questions are "non-standard" questions, meaning that the scope and the required knowledge to answer these questions most likely not taught in the regular classroom (Tyul'kov et al., 2010). Other researchers found that the typical chemistry OSN questions consist of questions that ask conceptual and procedural knowledge (Sunggarani et al., 2014). Abernathy and Vineyard found that students that compete in science olympiads stated that their reason to compete is to have fun and to learn new thing (Abernathy & Vineyard, 2001). Students also believe that their participation in the science olympiads are improving their twenty-first century skills, which include their ability to think critically (Sahin et al., 2014).

Based on the explanation above, it is necessary to have an instrument that can measure the critical thinking ability of students that participate in OSN. This instrument must

met the criteria of 1) validity; 2) reliability; 3) discrimination power; and 4) level of difficulty.

METHODS

This research is categorized as an R & D, which sought to develop a test instrument to measure the critical thinking ability of students that participate in OSN. The procedure that is used in this research is Four-D (4-D) model, consists of define, design, development, and disseminate, as suggested by Thiagarajan et al., (1974). The first step, define, consists of front-end analysis, learners analysis, concept analysis, task analysis, and specifying of instructional objectives. The next stage is seen to involve the design of prototype instructional material and to comprise four steps: construction of criterion referenced tests, media selection, format selection, and initial design for presentation of instrument. The developmental stage is said to comprise modification of the prototype material through expert appraisal and developmental testing. Described for the final stage (disseminate) are summative evaluation and diffusion by writing the scientific article about the research.

The method used in this research is test and non-test method. The test instrument used is a multiple choices test. Non-test instruments include expert validation sheets, questionnaires and interview sheets, the descriptive analysis used. The content quality of the instrument is analyzed from the data that is gathered by the developmental testing, and statistical analysis is used.

RESULTS AND DISCUSSION

The instrument that is developed consists of two parts, understanding argument and arranging arguments, in the form of 25 multiple choices questions that covers a wide range of topics from the OSN syllabus. A good instrument must meet the criteria of validity that comprises of content and construct validity (Sugiyono, 2009). The validity of the test instrument in this research is determined by the help from two experts by using a validation sheet provided by the researcher. The average values of response percentage from experts show that the instrument met the criteria of validity. The results of the expert validation are presented in Table 2.

Table 2. Recapitulation of Validation Results of Research Instruments

Aspects	Expert Validator		Average
	1	2	
Contents	15	15	15
Constructs	29	29	29
Language	14	13	13,5
Total score	58	57	57,5
Maximum score	64	64	64
Response percentage	90,6%	89,1%	89,8%
Category	Very good		

The instrument then can be used to gather data in the research. The next stage is the small-scale developmental test. The instrument that has been validated by the expert is tested to 10 students, and their response to the test is compiled. The reason for doing this small-scale test is to make sure that the instrument could be understood and used by the students. The indicators of critical thinking ability that are included in the test instrument are 1) analyse arguments; 2) observe, and judge observation reports; 3) use their background knowledge, knowledge of the situation, and previously established conclusions; 4) deduce, and judge

deductions; 5) make, and judge, inductive inferences and arguments; 6) make, and judge, value judgements; 7) define terms, and judge definitions; and 8) deal with things in an orderly manner.

The next stage is developmental testing of the instrument. Validated instrument was tested to 10 students to know whether the instrument were readable by the students. This small-scale testing shown that the instrument was readable and could be tested in a larger scale of developmental testing. The developmental testing was done to 36 students who participate to the selection process in the OSN. The quality of the instrument that is being developed is determined from the data gathered from this testing. The reliability of the instrument is analysed from the data. The instrument is found to be reliable. The Kuder-Richardson index (KR-20) of an instrument can have value from 0 to 1. The larger the value means that the instrument is more reliable. But, if the value of KR-20 is larger than 0,90 then this means that the test is done to homogeneous population. The reliability analysis result is presented in Table 3.

Table 3. Reliability Analysis of the Instrument

Item	Value/Category
KR-20	0,830
Decision	Reliable

The discrimination power of each question is analyzed, and it is found that 68% of the questions categorized as having "enough" and the rest of the questions categorized as having "good" discrimination power. The summary of the discrimination power of the instrument is presented in Table 4.

The next analysis is done to determine the difficulty level of each questions in the instrument. It is found that the average difficulty level of the questions in the instrument is 0,613 that fall in the category of "medium difficulty." The summary of the difficulty level of the instrument is presented in Table 5.

The result of this research shows that the instrument that is being developed to measure the ability level of critical thinking of the students have already met the criteria of a good instrument. The validity, reliability, discrimination power, and difficulty index are within range if the acceptable criteria of instrument.

Table 4. Summary of the Discrimination Power of Questions

Discrimination Power Range	Category	Number of Questions
DP ≤ 0,20	"Bad"	-
0,20 ≤ DP ≤ 0,40	"Enough"	17
0,40 ≤ DP ≤ 0,70	"Good"	8
DP ≥ 0,70	"Very Good"	-

CONCLUSION

Based on the analysis of the results and discussion of this research these conclusions can be taken: 1) the instrument to measure the critical thinking of students who participate in the National Science Olympiad consist of 2 parts that contain 25 questions in total; 2) the statistical analysis of the instrument shown that the instrument is valid, reliable, have sufficient discrimination power and difficulty level. Teacher who wants to use this instrument to measure the critical thinking ability of their students may do so, and the researchers that want to expand this research may consider to cover more topics and indicators that is not yet covered in this research.

REFERENCES

Abernathy, T., and Vineyard, R. (2001). Academic Competitions in Science. What Are the Rewards for Students? *The Clearing House*. 74 (5), 269-276.

Kemendikbud. (2016). *Panduan Seleksi Olimpiade Sains Tahun 2016*. Jakarta: Kemendikbud.

Kemendikbud. (2018). *Panduan Pelaksanaan Olimpiade Sains Nasional 2018*. Jakarta: Kemendikbud.

Sahin A., Gulacar, O., & Stuessy, C. (2014). High School Students'Perceptions of the Effects of

International Science Olympiad on Their STEM Career Aspirations and Twenty-First Century Skill Development. *Journal Research in Science Education*. Dordrecht: Springer.

Sunggarani, T., Nursa'adah, E., & Yunita. (2014). Analisis Soal-Soal Olimpiade Sains Nasional (OSN) SMA/MA Bidang Kimia Tahun 2012 Dan 2013 Berdasarkan Dimensi Proses Kognitif Dan Pengetahuan. *J. Pijar MIPA,* 9(2): 78 – 83.

Thiagarajan, S., Semmel, D.S., & Semmel, M.I. (1974). *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*, Minnesota: Leadership Training Institute.

Tyul'kov, I.A., Zefirova, O.N., Arkhangel'skaya, O.V., Koltyrev, D.Yu., and Lunin, V.V. (2010). A Historical Study of the Goals and Problems of Chemistry Olympiads for School Students. *Moscow University Chemistry Bulletin*. 63(4): pp. 236–239.