

Analysis of Students' Analytical Thinking Skills in Responding to the Development of the Industrial Revolution 4.0

Fakhrurrazi^{1, a)}, Sajidan^{2, b)} and Puguh Karyanto^{3, c)}

¹*Master Study Program of Science Education, Master of Biology Education, Faculty of Education, Universitas Sebelas Maret, Surakarta, Indonesia*

²*Study Program of Biology Education, Biology Education, Faculty of Education, Universitas Sebelas Maret, Surakarta, Indonesia.*

³*Study Program of Biology Education, Biology Education, Faculty of Education, Universitas Sebelas Maret, Surakarta, Indonesia.*

^{a)}Corresponding author: fakhrurrazi291@gmail.com

^{b)}sajidan@fkip.uns.ac.id

^{c)}karyarina@yahoo.com

Abstract. Competitiveness in the era of industrial revolution 4.0 requires students have more thinking skills, especially in solving problems related to local and global issues. One way is through learning process by empowering analytical thinking skills. This study aims to determine the profile of analytical thinking skills of MAN 2 Surakarta students. The subjects in this study were 90 students consisting of 3 classes. The instrument used in this study was a test using multiple choice questions developed based on indicators of analytical thinking skills according to Marzano and Kendall. Data were analyzed by qualitative descriptive method. Based on data analysis, the average analytical thinking skills of students were obtained by 43.8% (low category). The percentage of adjustment aspects was 51.3% (low category), the classification aspect was 46.0% (low category), the error analysis aspect was 39.4% (very low category), the generalization aspect was 47.6% (low category), and the specification aspect 30% (very low category). The results of this study provide information the profile of analytical thinking skills of students is still low, so the teacher is expected be able to design a learning process that can empower students' analytical thinking skills in responding development of industrial revolution 4.0 era.

INTRODUCTION

Globalization has entered a new era called Industry 4.0. The term Industry 4.0 was born from the idea of the fourth industrial revolution. Klaus Schwab through The Fourth Industrial Revolution states that the history of the world industrial revolution has undergone four stages of revolution [1], namely: 1) The Industrial Revolution 1.0 occurred in the 18th century through the discovery of steam engines, allowing goods to be mass produced, 2) Industrial Revolution 2.0 occurred in the 19th century through the use of electricity, assembly lines enabled mass production to make production costs cheap, 3) Industrial Revolution 3.0 occurred around the 1970s through computerized use, allowing one to program machines and networks. and 4) the 4.0 industrial revolution itself occurred around the year 2010 through the engineering of intelligence and internet of things (IoT) as the backbone of the movement and connectivity of humans and machines.

The Industrial Revolution 4.0 fundamentally results in changing the way humans think, live, and relate to one another. This era will disrupt various human activities in various fields, not only in the field of technology, but also in other fields such as economics, social, and education. Can be seen in the world of education the role of the teacher who has been the only knowledge provider has shifted away from him. In the future, the industrial revolution 4.0 era

and the presence and presence of teachers in the classroom will be increasingly challenging and require very high creativity.

If the role of educators still maintains as a one-way knowledge provider (teacher center), then they will lose their role along with technological developments and changes in their learning methods. This condition must be overcome by increasing the competence of educators who support knowledge for exploration and creation through independent learning.

It is said that the 21st century or entering the era of industrial revolution 4.0 is a century that demands quality in all efforts and results of human labor. By itself the 21st century calls for quality human resources, which are produced by professionally managed institutions that produce superior results. The new demands demand various breakthroughs in thinking, drafting and actions. In other word a new paradigm is needed in the face of new challenges, said philosopher Khun. According to philosopher Khun, if new challenges are faced by using the old paradigm, then all efforts will fail. The new challenge demands a breakthrough thinking process if what is desired is quality output that can compete with the work in an open world [2].

In the context of 21st century learning the use of various learning activities that support 4.0 is a must with resource sharing models with anyone and anywhere, class learning and labs augmented with virtual material, are interactive, challenging, and content-rich learning is not just complete.

Minister of Education and Culture (Mendikbud) Muhadjir Effendy said that his ministry had prepared a standard for specific learning strategies to deal with the 4.0 industrial revolution. The preparation is to redesign (redesign) the educational curriculum that has five potentials, namely (1) critical thinking skills, one of which is analytical thinking, where education must make students have deep, broad and open thinking skills, (2) children's creativity learners. In the face of the 4.0 industrial revolution, the Minister of Education hopes that the curriculum redesign can produce creative and innovative students, (3) Ability and communication skills where students must have communication skills so that they have skills, (4) collaborate and collaborate, so students must work and collaborating with others, and (5) presenting a confidence or confidence. Making students who have high self-confidence so that it becomes capital in facing the 4.0 industrial revolution.

Implicitly, the emergence of the HOTS problem was one of them with analytical thinking skills as the Ministry of Education's initial strategy to prepare students to face the 4.0 industrial revolution. For that our attitude as teachers must be able to present learning in a fun class and provide learning strategies according to the 2013 Curriculum which train high order thinking skills, one of them is analytical thinking skills.

In the learning process, in addition to achieving existing goals, students need to be equipped with certain abilities so they are able to develop and evaluate arguments in solving certain problems. One of the abilities that must be developed to achieve these goals is analytical thinking skills. A student is said to have analytical thinking skills if he has a systematic way of thinking, awareness in thinking, and has the ability to distinguish between truth and error. Thus, a teacher needs to make maximum efforts so that students have good skills in analytical thinking by conducting a variety of learning processes both approaches, methods, or innovative learning models so that the objectives proclaimed are successfully achieved.

Improving the quality of education in the era of industrial revolution 4.0 is a necessity that cannot be postponed. This is because the success of developing a nation's quality is mainly determined by the existence of quality human resources. Empowerment of analytical thinking skills will give birth to students who can decipher a problem into smaller parts (components) and be able to understand the relationships between these parts, and will produce ideas that will be able to compete globally [3].

Empowering analytical thinking skills in the era of industrial revolution 4.0 is absolutely necessary. Analytical thinking skills are one of the high-level thinking skills that must be trained and require special attention. Analytical thinking skills greatly influence the formation of student conceptual systems. Analytical thinking style is included in type A thinking style, which includes logic, factual, critical, technical, analytical, and qualitative [4]. During this time, analytical thinking skills have not received special attention in schools even though analytical thinking skills are one of the determinants of the success of learning this century. Analytical thinking skills are very necessary in scientific reasoning to prove the concepts that are built are really supported by parts of the concept [5].

[6] states that empowering analytical thinking skills influences how students think and provides research-based theories to help teachers improve student thinking. Analytical thinking skills are useful for adapting and modifying information and include cooperation that is useful in everyday life [7]. Analytical thinking is very important for the success of professional students in the future [8].

Then [9] also suggests that there are five indicators of cognitive processes in the process of analytical thinking, namely: matching, classifying, analyzing errors, generalizing and specifying. In more detail, [10] mentions analytical thinking processes as in Table 1.

TABLE 1. Analytical thinking skills

Indicator	Description
Matching	Matching processes address the identification of similarities and differences between knowledge components.
Classifying	Classifying refers to organizing knowledge into meaningful categories
Analyzing errors	Identifying misunderstanding of knowledge or improper application of processes
Generalizing	process of constructing new generalizations from information that is already known or observed.
Specifying	Making predictions about what will happen in a given scenario

Based on the explanation above, this study aims to examine the empowerment of students' analytical thinking skills in addressing the development of the industrial revolution 4.0. The benefits of this study are expected to provide an overview of the urgency of students' analytical thinking skills in responding the development of the industrial revolution 4.0 era.

EXPERIMENTAL DETAILS

This type of research is a descriptive study with a qualitative approach. Qualitative research is a study that is intended to understand the phenomenon of what is experienced by research subjects, holistically by means of descriptions in the form of words and languages in a specific natural context by utilizing various scientific methods [11]. Descriptive research is research that depicts what it is about something variable, symptom or about a situation [12].

The aim is to describe analytical thinking skills qualitatively based on quantitative data. The research design used is a simple descriptive design, which describes an achievement of a particular group of subjects without manipulating the treatment and is intended to retrieve direct information in the field, namely analytical thinking skills of students of class XII IPA MAN 2 Surakarta. The samples in this study were three XII IPA classes namely Class XII IPA 1, Class XII IPA 2, and Class XII IPA 3 MAN 2 Surakarta, totaling 90 students. Data collection techniques using tests. The test instrument used was a multiple choice of 30 items and was oriented towards indicators of analytical thinking skills. The collected data was then analyzed using qualitative descriptive analysis based on Indicators of Analytical Thinking Skills (IATS) in [13] research, namely: (1) matching, (2) classifying, (3) analyzing errors, (4) generalizing, and (5) specifying. The method for calculating the percentage value is then processed with reference to [14] as follows:

$$\text{Nilai Persentase} = \frac{\text{Skor Perolehan}}{\text{Skor Maksimal}} \times 100\%$$

The percentage value of analytical thinking skills obtained from the calculation is then categorized according to Table 2.

TABLE 2. Percentage categories of analytical thinking skills

Interpretation (%)	Category
$81,25 < X \leq 100$	Very high
$71,50 < X \leq 81,25$	High
$62,50 < X \leq 71,50$	Medium
$43,75 < X \leq 62,50$	Low
$0 < X \leq 43,75$	Very Low

RESULT AND DISCUSSION

Analytical thinking is included in high order thinking skills. This statement is explained in [15] study which states that analytical thinking skills are one of the high order thinking skills that must be trained and require special attention. Analytical thinking skills greatly influence the formation of student conceptual systems. The same is

explained by Krathwohl [16], that analytical thinking skills are included in high order thinking skills. While [17] states that analytical skills are skills to identify the main arguments presented. Further analytical thinking skills can be defined as a skill for detailing or describing a problem into smaller parts (components) and being able to understand the relationships between these parts. Analytical thinking skills are very necessary in scientific reasoning. The Ministry of Education and Culture formulates that the 21st century learning paradigm emphasizes the ability of students to find out from various sources, formulate problems, think analytically, and cooperate in solving problems [18].

According to [19] analytical thinking skills as problem solving are needed in the learning process, because learning designed with a learning approach oriented to analytical skills cannot be separated from a combination of thinking skills and creativity skills for problem solving.

Based on the results of analysis of analytical thinking skills tests, data obtained that the average student analytical thinking skills are still relatively low. The low analytical thinking skills of students of class XII IPA MAN 2 Surakarta were obtained from the results of student work on the test questions used. The results of each aspect of the student's analytical thinking indicators as shown in Figure 1.

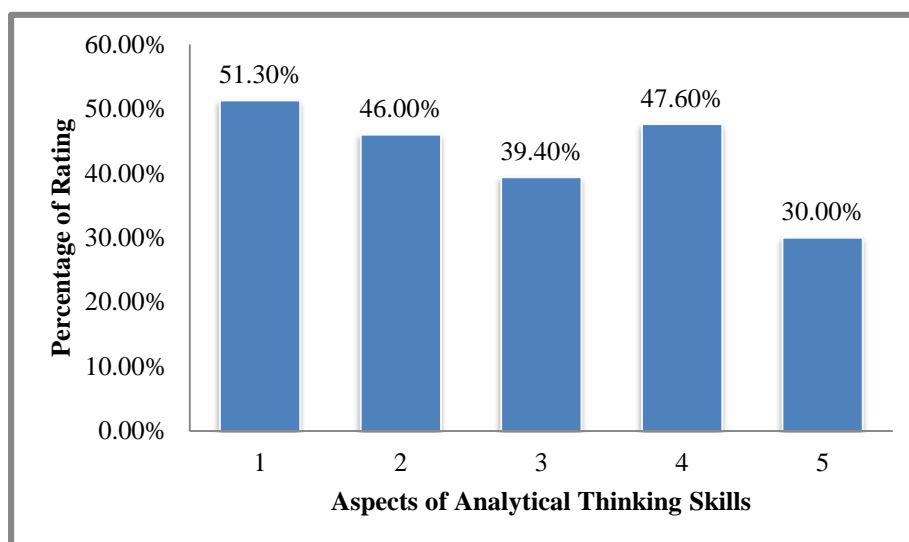


FIGURE 1. Percentage Chart of Achievement of Student Analytical Thinking Skill

1: Matching; 2: Classifying; 3: Analyzing Error; 4: Generalizing; 5: Specifying.

The average results of the percentage of students' analytical thinking skills of 43.8% belong to the low category. The percentage in the matching aspect was obtained at 51.3% in the low category, the classifying aspect of 46.0% belonged to the low category, the analyzing errors aspect was 39.4% in the very low category, the generalizing aspect was 47.6% in the low category, and the 30% specifying aspect was very low .

The results obtained from each indicator show that students' analytical thinking skills in the concept of the motion system in humans are in the low category. The following is the percentage of observations of students' analytical thinking indicators:

1. Matching Indicator

The results of the cognitive test sheet analysis on learning material of motion system in humans. Analytical thinking skills on matching indicators show a low category, this is evidenced from the results of the acquisition of cognitive test sheets with a percentage of 51.3% in the low category. It can be said that students have been able to answer questions, are able to interpret phenomena but are less complete and less precise in categorizing an answer on an adjustment indicator, namely in identifying similarities and differences. As students have not been able to analyze bones that have similar functions, they cannot yet classify bones in the human body and so on.

2. Classifying Indicator

The second indicator of analytical thinking skills is classifying, namely the ability to identify various subordinate categories for a concept and explain relationships based on their basic attributes. The classifying indicator in analytical thinking skills is the ability of students to choose concepts to be classified or identify various categories

for a concept of motion systems in humans and explain their relationships. Based on the analysis of the test questions analytical thinking skills on this indicator showed that each of 46.0% was in the low category, namely students had not been able to analyze the types of bones making up human skeletons, confirmed the forms of human skeletal bones, linking joint function to the motion system humans and explain the types of muscles in the human motion system.

3. Analyzing Errors Indicator

The third indicator of analytical thinking skills is Analyzing errors, the percentage of only 39.4% is still in the very low category. Students are still unable to identify misunderstandings of knowledge or the application of improper processes. after further analysis, students in this category have not been able to examine bone structure in the human motion system, analyze various joints in the human motion system, analyze various types of muscle movements in the human motion system and examine the mechanism of muscle contraction in humans. This means that students lack understanding of the problems presented, write the right facts, plan procedures for solving problems, and evaluate decisions correctly.

4. Generalizing Indicator

Based on the results of the percentage of students' analytical thinking skills on generalizing indicators, it was found that 47.6% were included in the low category. This means that students have not been able to conclude comprehensively a number of concepts and principles from a set of knowledge that has been learned. This means that students have not been able to detect various types of disorders of bone, joints and human muscles. Generalization skills are one of the stages to teach or train students to be able to think analytically, students are required to be able to describe and understand various aspects in stages to arrive at a new formula, namely a conclusion.

5. Specifying Indicator

Based on the results of the analysis of cognitive tests analytical thinking skills on the specifying indicators showed that the percentage of 30% was in the very low category. The acquisition of cognitive tests with competency achievement items such as formulating efforts to prevent bone and joint disorders and diseases in humans is not yet complete. The achievement of specifying indicators is still not mastered by students in practicing analytical thinking skills.

Based on the results of the analysis of indicators of analytical thinking skills namely, matching, classifying, analyzing errors, generalizing, and specifying. These five indicators are still in the low category. This happens because the teacher has not accustomed students to practice analytical thinking. [20] which states that most teachers only teach formulas and then students are asked to memorize them.

Content standards according to the National Education Standards Agency (BSNP) remind us that the nature of learning is not limited to products, attitudes but also learning as a process. Therefore it is expected that in teaching and learning activities students are given space to be directly involved in the process of constructing the material they are learning. The results of student interviews show that students pay less attention to the important information in the problem so that students have difficulty in analyzing the problem. [21] states that even though students know a concept but not necessarily students can know how to apply it / use it. There are still many students who find it difficult to apply knowledge and concepts that they know to solve problems indicating that students must practice a lot in applying the concepts or knowledge they have so that their analytical thinking skills can be empowered.

Students' analytical thinking skills that are still relatively low indicate that there needs to be an evaluation of the process of learning activities used in the classroom, because basically analytical thinking skills of students can be trained and honed in the learning process. Especially nowadays analytical thinking skills are a basic skill that students must possess.

The desired education in the 21st century or the industrial revolution era 4.0 is more directed at the aspects of high order thinking skills one of which is analytical thinking [22]. Empowering analytical thinking skills is in line with those formulated by the Ministry of Education and Culture that the 21st century learning paradigm or the 4.0 industrial revolution era emphasizes the ability of students to find out from various sources, formulate problems, analytical thinking and collaboration and collaborate in solving problems [23].

[24] revealed a mindset that is something that can be shaped in accordance with the desired goal. Analytical thinking skills are the basis of orderly and systematic thinking. Through analytical thinking we can decipher the problem like describing tangled threads. Some analytical characteristics are (1) systematic thinking, (2) high discipline, (3) respecting the facts presented logically, (4) liking things organized, (5) being careful and focused on the details of the problem.

[25] states that there are several ways to improve analytical thinking skills including: a) reading and analyzing; b) increasing the power of analyzing a problem in a discussion and finding the best solution and analyzing the worst

impact of the problem; c) developing the ability to observe or observe further mention of the strengths and weaknesses, the pros and cons of the problems observed are expected to explore students' analytical abilities; d) increase curiosity, ability to ask and reflect, submit quality questions, namely questions that do not directly have the right or wrong answers or not just one correct answer so that students demand active thinking. Analytical thinking skills can be improved by implementing student-centered learning [26].

Another effort that can be taken is by providing training for teachers on how to develop students' analytical thinking skills. [27] presents the results of his research that teacher education and training not only aims to enable teachers to develop students' analytical thinking skills, but also allows teachers to develop analytical processes in education, curriculum, and students. The teacher must facilitate the development of students' analytical thinking through learning done in class. [28] describes the drafting of complete learning activities to be carried out in classrooms, laboratories, as well as providing direct experience for students needed to develop good analytical thinking skills.

Based on the results of the above research, analytical thinking skills still need to be trained and improved by teachers and schools. Because change and development of education must refer to the demands of the era, namely the era of industrial revolution 4.0, an era where students must be able to adapt to technology and the latest innovations, thinking skills are needed in realizing that. The skills that must be honed are high order thinking skills (HOTS), one of which is the ability to think analytically. Finally quoting Jack Ma at the 2018 World Economic Forum annual meeting, education is a big challenge of the century. If you don't change the way you educate and teach, in the next 30 years you will experience great difficulties.

SUMMARY

Based on the results of data analysis and discussion it can be concluded that the analytical thinking skills of students of MAN 2 Surakarta are relatively low. This is indicated by the results of tests of students' analytical thinking skills. The results of this study can provide information to students, teachers and the school so that teachers are expected to be able to present learning activities that can empower students' analytical thinking skills so that the education mandate in the era of industrial revolution 4.0 can be fulfilled. Suggestions that can be conveyed by researchers based on the results of this study are: 1) to teachers and the school are advised to be able to design teaching and learning activities that can empower students' analytical thinking skills; 2) to the next researcher it is recommended to use indicators of analytical thinking skills based on other experts, such as Anderson and Krathwohl, Paul & Elder and others; 3) other researchers should conduct analytical thinking skills on different material and different subjects.

ACKNOWLEDGMENT

We would like to thank the side of MAN 2 Surakarta for their assistance and cooperation in the implementation of this activity so that research and journal writing can be completed well and on time.

REFERENCES

1. K. Schwab, *The Fourth Industrial Revolution*, (Crown Business, New York, 2016).
2. H. A. R. Tilaar, *Beberapa Agenda Reformasi Pendidikan Nasional dalam Perspektif Abad 21*, (Tera Indonesia, Magelang, 1998).
3. T. D. Hofreiter, Monroe and Stein, *Teaching and Evaluating Critical Thinking in an Context*, (School Of Forest and Resources and Conservation, Florida, 2007).
4. M. Razali, R. Jantan and S. Hashim, *Psikologi Pendidikan*, (PTS Professional, Malaysia, 2007).
5. N. Muhsin and S. Budiani, *Logika.*, (Universitas Terbuka, Jakarta, 2010).
6. R. J. Marzano and J. S. Kendall, *The New Taxonomy of Educational Objectives*, (Corwin Press, Thousand Oaks, California, 2007).
7. Pennycook, Fugelsang and Koehler, "Everyday Consequences of analytic Thinking." in *Current Direction in Psychological*, (2015), pp. 425 - 453.
8. F. Eckman, "Using the WebCT NAFTA Program to Promote Analytical Thinking and Global Awareness Competencies Through a Team Approach." in *International Textile & Apparel Association*, (2005), pp. 278-289.

9. R. J. Marzano and J. S. Kendall, Op.cit.
10. J. M. Dubas, and Toledo, "Taking Higher Order Thinking Seriously : Using Marzano's Taxonomy in the Economics Classroom." in *Journal International Review of Economic Education*, (2016), pp. 12-20.
11. L. J. Moleong, *Metode Penelitian Kualitatif*, (Remaja Rosdakarya, Bandung, 2013).
12. S. Arikunto, *Prosedur Penelitian : Suatu Pendekatan Praktek Edisi 3* (Rineke Cipta, Jakarta, 2000).
13. R. J. Marzano and J. S. Kendall, Op.cit.
14. Karim and Normaya, "Kemampuan Berpikir Kritis Siswa dalam Pembelajaran Matematika dengan Menggunakan Model Jucama di Sekolah Menengah Pertama." in *Edumat Jurnal Pendidikan Matematika*, (2015), pp. 92-104.
15. Q. Zhou, Q. Huang and H. Tian, "Developing Student's Critical Thinking Skills By Task Based Learning in Chemistry Experiment Teaching." in *Creative Education*, (2013), pp. 40-45.
16. N. Lewy, "Pengembangan Soal untuk Mengukur Kemampuan Berpikir Tingkat Tinggi Pokok Bahasan Barisan dan Deret Bilangan di Kelas IX Akselerasi SMP Xaverius Maria Palembang." in *Jurnal Pendidikan Matematika* (2009).
17. T. D. Hofreiter, Monroe and Stein, Op.cit.
18. Litbang Kemdikbud, *Kurikulum 2013: Pergseran Paradigma Pendidikan Abad 21* ,(litbang.kemdikbud.go.id, 2013).
19. R. Harsanto, *Melatih Anak Berpikir Analitis, Kritis, dan Kreatif*, (Gramedia, Jakarta, 2005).
20. M. Kusumaningrum dan Abdul AS, *Mengoptimalkan Kemampuan Berpikir Matemaika melalui Pemecahan Masalah Matematika*, (Prosiding Seminar Nasional Penelitian dan Penerapan MIPA, 2012)
21. J. Carson, "A Problem with Prolem Solving: Teaching Thinking without Teaching Knowledge" in *The Matematics Educator Journal*, (2007), pp. 7-14.
22. J. L. S. Ramos, Dolipas and Villamor, "Higher Order Thinking Skills and Academic Performance in Physics of College Student : A Regression Analysis." in *International Journal of Inovative Interdisciplinary Research* (2013), pp. 48-60.
23. Litbang Kemdikbud, Op.cit.
24. R. Sofrani, J. Kartika and A. Suhita, *Breakthrough Thinking: Bagaimana Cara Para Inovator Berpikir*, (Elex Media Komputindo, Jakarta, 2009).
25. Eggen and Don, *Strategic and Models for Teachear: Teaching Content and Teaching Skills, Sixth Edition.*, (Index, Jakarta, 2012).
26. T. K. White .et al, "The Use of Interrupted Case Studies to Enhance Critical Thinking Skills in Biology" in *Journal of MicroBiology and Biology Education*, (2009), pp. 25-31.
27. L. Radulovic and Stancic, "What is Needed to Develop Critical Thinking in School." in *C.E.P.S Journal*, (2017), pp. 9-25.
28. E. Istiyono, D. Mardapi and Suparno. "Pengembangan Tes Kemampuan Berpikir Tingkat Tinggi Fisika (PysTHOTS) Peserta Didik SMA." in *Jurnal Penelitiandan Evaluasi Pendidikan*, (2014), pp. 1-12.