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Improving higher order thinking skills in high school biology: A systematic review

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A R T I C L E   I N F O

A B S T R A C T

This research aims to analyze the approaches and strategies used to improve high school students' Higher Order Thinking Skills (HOTS) in Biology. The research reviewed 36 articles written by scholars from Indonesia and overseas. These articles sourced from various digital libraries of universities in Indonesia, and online databases such as Google scholar, Elsevier-Science Direct, Springer, Wiley, and Taylor & Francis Online. This review followed the PRISMA-P for systematic review protocol. All articles were further reviewed and assessments based on the research design, variables, approaches to improve student's HOTS. Research trends in HOTS research the most widely used instructional model to improve HOTS are PBL, Inquiry learning, and Discovery learning. Based on the analysis, INSTAD (Inquiry+Student Team Achievement Division), and PBI+STAD (Problem Based Learning + Student Team Achievement Division) shows no improvement in students' HOTS. Application of other learning models such as Problem Based Learning (PBL), inquiry, discovery, Advance Organizer, POE (Predict, Observe, Explain), and BBL (Brain Based Learning) shows significant improvement on students' HOTS. Implementation of instruction using Laboratory activities, mixed methods learning and Nutriscore interactive media shows improvement on students' HOTS. From 36 articles, 2 articles indexed by SCOPUS, 15 indexed by SINTA, 8 proceedings, 9 theses, and 2 unindexed articles. Not every chapter in Biology is used in these articles. The most used chapter in the articles is ecosystem and environment followed by human physiology, fungi, protists, plantae, cell, and biotechnology. Most of the articles are using Bloom's taxonomy. Each of them used different taxonomy, which is Marzano's taxonomy and Gagne's taxonomy.

INTRODUCTION

Based on the results of the PISA (Program International Student Assessment) - a three-year program to assess literacy skills in reading, science, mathematics, and several important competencies of 15 year old students from various participating countries - in 2015, Indonesia ranked 64th out of 72 countries, then in 2018, Indonesia occupied the position of 73 out of 79 participating countries (OECD, 2016, 2018). Thus, it is necessary to make efforts so that the abilities of Indonesian students are not always less competitive with students from other countries.

Efforts to improve student abilities in Indonesia are carried out by improving students' higher order thinking skills. This effort is carried out by applying appropriate learning models to improve students' higher-order thinking skills (Directorate General of Teachers and Education Personnel, 2018); improved assessment (Barak & Dori, 2009); improvement of learning resources (Hopson, Simms, & Knezek, 2001); teacher training (Salirawati et al., 2017); and curriculum improvement (Putra, Muttaqin, & Setyarini, 2017).

Many studies have been conducted to improve students' higher order thinking skills. The first research and review article with the theme HOTS in Indonesia was first published in the Jurnal Pengajaran Matematika dan IPA 2001 by Liliasari. The results show HOTs had successfully increased the science teacher candidates' way of thinking, on the whole stages of critical thinking skills, that have raised their propositional and combinatorial thinking. The impact shows that science models of learning (MPIPA) are available as a new trend of science teacher training for the globalization era (Liliasari, 2001).

To find out how broadly the HOTS issue is researched and applied, it is necessary to analyze and review research articles that raise the HOTS topic in several proceedings, journals, and theses / theses / dissertations published within a certain period of time. This analysis and review needs to be carried out systematically to obtain a broad and detailed picture. The approach used in this study is systematic review (SR). Systematic Review is a literature review equipped with methods to reduce bias, generally by identifying, assessing and analyzing relevant study results to answer questions (Petticrew & Roberts, 2005). Research using SR aims to answer specific, relevant, and focused questions (Hariyati, 2010).

The objectives of this study are: 1). Analyze HOTS-based learning models and methods, 2). Analyzing the HOTS measurement instrument, 3). Analyzing the diversity of Biology material in HOTS research in high school, 4). Analyze the types of learning taxonomies used in HOTS-based learning research, 5). Analyze HOTS learning research trends

METHODS
Research Design

This research is qualitative research. The design of this research is document analysis research, in the form of a Systematic Review (SR). This SR study used the PRISMA-P protocol, which was adopted from (Moher et al., 2015). The detailed steps on our literature review are: Selection of the study population. The articles we used were obtained from an online database. The source of the articles to be analyzed comes from the thesis of teacher education students at the scientific articles published in national journals, proceedings, and international journals. We limit our research only in 2001-2019. Higher Order Thinking Skills (HOTs) is a learning method that is known and used widely throughout the world. Understanding of this concept has existed since the beginning of the 20th century and was introduced in Indonesia around the 2000s. Higher Order Thinking began to be widely applied after the Indonesian government imposed regulations to implement the 2013 curriculum in Indonesian schools. The search was carried out on the online databases of Google scholar, Elsevier-ScienceDirect, Springer, Wiley, and Taylor & Francis Online.

The next sub-step is determining the criteria for selecting the articles that will be used. The inclusion criteria set were: 1). Documents selected in Indonesian or English, 2). The document used discusses the improvement of higher order thinking skills at the senior high school level, 3). The document uses the keywords "higher-order thinking" and "High School Biology" which appears in the article title, 4). Article published in 2001 to 2019 during the writing process of this paper. The exclusion criteria applied were: 1). We exclude articles which are not available in their entirety, 2). We exclude articles that contain only abstract. After the search process, the collected articles are then filtered to reduce duplicate articles that are collected. This process uses Publish or Perish 7 software. From the overall search results for each page, the document is then filtered based on its relevance with inclusion

and exclusion criteria. Furthermore, the documents that pass the screening process are included in the table for further analysis. Data analysis was carried out by narrative analysis. Narrative analysis follows three stages, namely: data management, intra-article analysis, and inter-article analysis (Petticrew & Roberts, 2005). The schematic review of this research is presented in Figure 1. The next step is Data collection. The data collection includes extraction of relevant information from the primary studies. After collection, the collected relevant data then analyzed narratively.
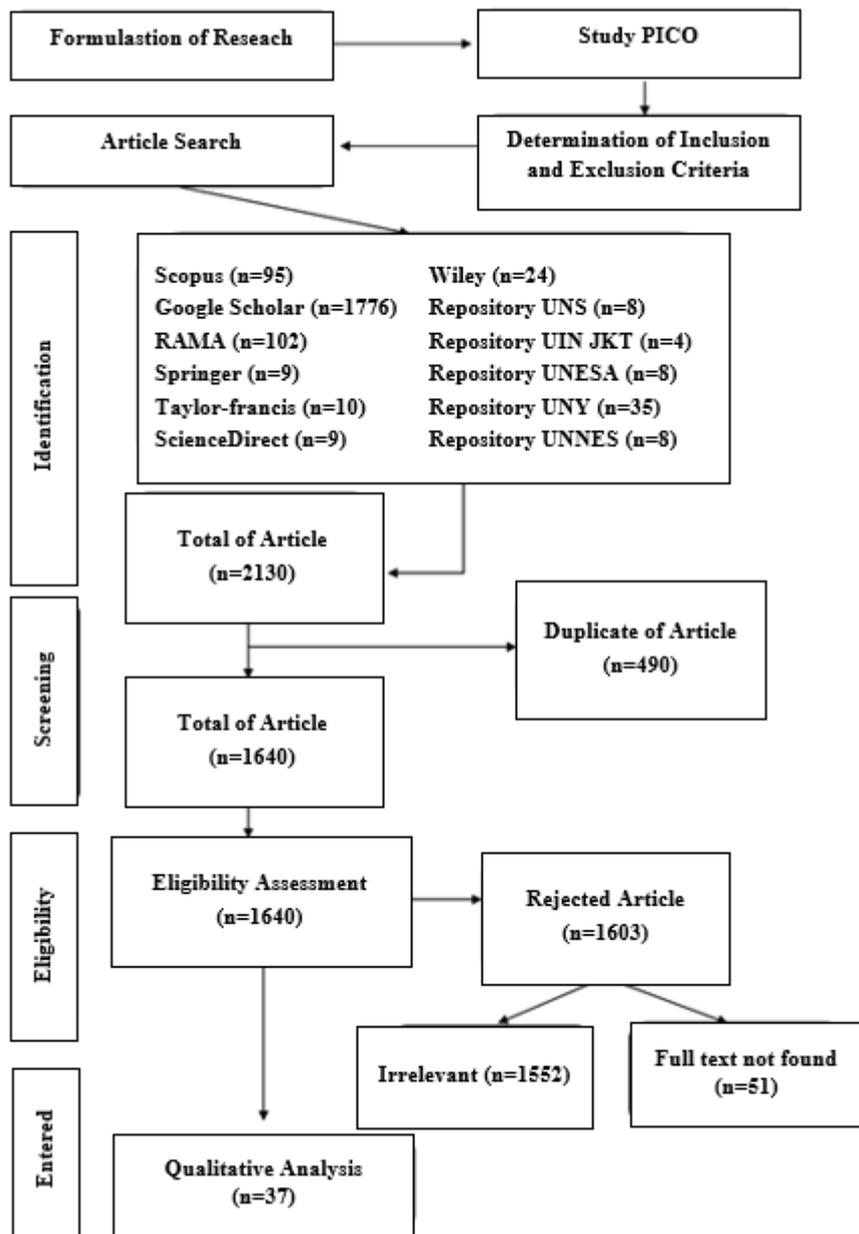

Figure 1. Systematic review flowchart

RESULTS AND DISCUSSION

The total number of traced articles were 2130 articles (2001-2019). After going through the duplicate screening process, the remaining articles were 1640. Then, after being filtered based on exclusion criteria, the remaining articles for analysis were 36 articles. A total of 32 articles are articles sourced from Indonesia, and 4 articles are international. The articles obtained are indexed in the Scopus index, the SINTA index (Sinta 2 to Sinta 6), undergraduate theses, proceedings, and articles that are not indexed. Before being selected for review, articles that are not indexed must first be checked whether the publisher or journal is included in the predatory publisher / journal.

Learning Model used to improve Students' HOTS

The search results article discusses various models for improving higher-order thinking skills. Data on the number of learning models in the HOTS study are presented in Table 1.

Table 1.
Data on the number of learning models

Learning Model / Method	Amount
Problem Based Learning	18
Inquiry Learning	5
Discovery Learning	4
Advance Organizer	1
Predict, Observe, Explain	1
Brain Based Learning	1
Group Investigation	1
PBI + STAD	1
INSTAD	1
PBL + Online Interaction	1
Interactive Media	1
Mixed Methods	1
Learning accompanied by practicum	1

A. Problem Based Learning

Based on the articles reviewed, there are 18 articles using the problem-based learning (PBL) model. The PBL model that is applied in the articles analyzed adopts the PBL developed by Tan (2009); Arends (2012); and Fogarty (1997). According to Prince & Felder (2007) There are several types of problems raised in PBL, namely existing problems (problems that exist in the real world) and original problems (problems that are made solely for problems). In the articles about HOTS empowerment that were analyzed, the PBL model that was applied raised problems from existing problems. The problems included problems that are close to student life so that the learning process is more contextual.

B. Inquiry Learning

There are two types of Inquiry learning models that are commonly found to improve higher-order thinking skills, namely Guided Inquiry and Free Inquiry. The inquiry model is claimed to be able to improve and train HOTS because the inquiry learning model is a constructivist-based learning model that gives students the opportunity to develop their knowledge independently. (Azizah & Prayitno, 2016).

When compared between the Guided Inquiry and Free Inquiry, the two results show that the results are not much different. The difference between the two is the size of the teacher's role in learning. In Guided Inquiry, the teacher is more dominant because it acts as a facilitator, while in Free Inquiry the teacher's role is only as a supervisor and helps students when needed. It's just that, the learning independence of students in the Free Inquiry class is higher when compared to students in the Guided Inquiry class (Wenning, 2005).

In the reviewed articles, the inquiry model applied is Guided Inquiry and Free Inquiry. The Inquiry Model in the analyzed articles is adopted from Scott, Tomasek, & Matthews (2010); and from Joyce & Weil (1972).

C. Discovery Learning

Discovery model is considered to improve HOTS because students learn through the discovery of scientific concepts. The application of the Discovery learning model can improve students' higher order thinking skills. The improvement of students' higher order thinking skills can be much higher if in its application it utilizes the potential that exists around the school so that learning is more contextual (Sulastri, 2014). According to students, the application of the Discovery learning model made students' curiosity and self-confidence in learning increased (Riandari, Susanti, & Suratmi 2018). The articles reviewed in this study adopted the discovery learning by Veermans (2003) and Muhibbin (2003).

D. Group Investigation

The Group Investigation (GI) learning model is a learning model that focuses on student cooperation in the learning process. The GI model is considered to be able to improve HOTS because the GI learning model trains students to reduce learning dependence on teachers and puts more emphasis on learning by solving problems with peers in the group.(Nur, 2012). The articles were reviewed using the GI adopted from Sharan & Sharan (1990). Advance Organizer. The Advance Organizer (AO) learning model is a learning model developed by David Ausubel in 1960. The AO learning model is assumed to be able to train HOTS because the AO learning model helps students organize and connect the initial knowledge that students have and the knowledge they get in the learning process. Yuda (2019). In the articles analyzed, the AO model used was adopted from Downing (1994).

E. Predict, Observe, Explain (POE)

The POE learning model has stages according to its name, namely Predicting, Observing, and Explaining. The POE model is assumed to be able to train HOTS because the POE model helps students in building hypotheses, conducting experiments and explaining experimental results (Suryamiati, Kahar, & Setiadi, 2019). PIn the article analyzed, the POE model used was adopted from Ayvaci (2013).

F. INSTAD

In article [N11], the learning model used is the INSTAD learning model. The INSTAD learning model is a combination of the Inquiry learning model and the Student Teams Achievement Division cooperative learning model. The INSTAD model is assumed to be able to train HOTS because the INSTAD model is intended to anticipate the weaknesses of more individual inquiry learning(Evi Nur, Karyanto, & Sugiharto, 2012). Based on the results of the research in the article, when compared, the high-order thinking skills of the treatment class and the control class were not significantly different. For teachers and researchers who want to apply the INSTAD model in learning, it is better to adjust the allocation of time in learning so that learning can be maximized.

G. PBI + STAD

In article [N3], the PBI + STAD model shows lower higher order thinking skills outcomes in the treatment class than in the control class. In fact, PBI + STAD is a learning model that combines problem-based learning and STAD which can train students to work in groups.This model is assumed to be able to train HOTS because the combination of these two learning models aims to anticipate the weaknesses of the problem-based learning model and the STAD cooperative model. Teacher skills in managing time and managing the class are also needed for the success of the PBI + STAD model (Nurjannah, Prayitno, & Ariyanto, 2012).

H. PBL + OI

The PBL-based learning module combined with Online Interaction modifies conventional PBL learning with learning sourced from the internet. 75% of the learning allocation is done face-to-face and the remaining 25% is allocated for finding sources of information and sharing information between students online. This model is assumed to be able to train HOTS because PBL combined with online interaction can improve students' higher order thinking skills because in learning, students are invited to learn more actively and collaboratively, and are able to develop ideas independently to solve problems.(Suwono & Dewi, 2019). In the article analyzed, the PBL + OI model used is adopted from Carrió, et al. (2011)which allocates 80% of PBL-based learning and 20% conventional lecture-based learning.

I. Brain Based Learning

Brain Based Learning (BBL) learning model is considered to be able to train HOTS because it combines 5 natural mechanisms in the human brain to harness its potential in learning. The five mechanisms are mobility, behavior, knowledge, physicality, and reflection. The BBL learning model also emphasizes the importance of students' readiness to learn, as well as the importance of a positive atmosphere in the classroom (Hermala, 2019).

J. Learning with additional laboratory activity

In article [I2], students' higher order thinking skills learned in the laboratory showed better higher order thinking skills results. This method can train HOTS because students who learn in the laboratory can more freely use the various senses in their body to learn. With this freedom, various types of student learning models can be facilitated properly(Hofstein & Mamlok-Naaman, 2007).

K. Learning with additional Laboratory activity

Learning steps with additional experiments in the laboratory were developed by Lee, et al. (2014). Learning in the laboratory is carried out 4 times in a period of 24 lessons in the classroom. Before doing the practicum, students and teachers plan to determine the hypothesis and material tools used in the practicum. Practicum is held for 45 minutes in one meeting.

L. Interactive Multimedia

Nutriscore is an interactive multimedia program aimed at improving students' level thinking skills. Research [I4] was conducted in Malaysia in 2018. This study uses Marzano's Taxonomy. Nutriscore multimedia was developed based on constructivism learning theory. This multimedia includes various images and video recordings of real learning objects taken by the developer. Various illustrations are included according to the material. In addition, Nutriscore multimedia is equipped with an assistant character in the form of animation in multimedia. Nutriscore serves as an information provider, a mentor to help in the learning process, a motivator, a study partner. The result, there is a significant difference between the skills of students in the aspect of classifying and comparing the experimental class is higher than the control class.

HOTS Measuring Instrument.

HOTS measurement instrument data are presented in Table 5.

Table 5.

HOTS measuring instrument

HOTS Measuring Instrument	Amount
Description	20
Multiple choice	6
Combination	4
Not explained	3
Problem solving test	2
Open Ended Question	1

The form of HOTS measurement instruments can be grouped into two groups, namely standardized instruments and instruments that were modified by researchers themselves. Standardized instruments are the instruments that are considered the best because they have gone through a detailed validation process to ensure the accuracy of measurements (Sommers, 2018).

Non-standardized self-developed instruments can cause problematic research results so that there may be differences between one article and another. In addition, the choice of using self-developed instruments compared to the use of standardized instruments is due to limitations in accessibility and cost. Standardized instruments use English, while the accessibility of students and researchers is to understand the contents of the instrument. Then, the large cost also becomes an obstacle. The cost of using the instrument can reach 15 million Rupiah for measuring the skills of 30 students per semester(Sulaiman & Azizah, 2020).

Examples of HOTS assessment questions are attached in the image obtained from article [N22]. Examples of these include LOTS and HOTS questions. The example question is in accordance with the opinion(Brookhart, 2010), that is, a question to measure student's HOTS generally attaches an introduction material as a material for students to think. Then, the questions to measure HOTS should use new questions that have never been taught in class. However, these questions must be specifically able to measure higher-order cognitive dimensions. Finally, the HOTS measure does not have to have a high level of difficulty.

The material used in the HOTS enhancement article.

There are various Biological Materials discussed in the search results article. not all material has been used in research on HOTS improvement. The material data is presented in Table 6.

Table 6.
Biological material in HOTS research

Material	Amount
Human Physiology	8
Ecosystem	6
Environment	5
Kingdom Plantae	1
Kingdom Animalia	1
Protists	1
Fungi	2
Biotechnology	1
Not mentioned	2
Cell	1
Nutrition	1

According to Vasminingtya, Sajidan, & Fatmawati (2014), the selection of materials related to ecosystems and the environment because these materials are very close to everyday life. In addition, these materials offer a lot of ill-structured problems for students to solve in learning. According to Nikmah, Anggraito, & Widiatningrum (2017) material related to human physiology was chosen because the process of human physiology is experienced by students in everyday life, but it is not easy to observe the process. On the other hand, sometimes students just realize that there are physiological processes that occur in their lives. HOTS training on articles with material related to human physiology accompanied by a direct experimental process so that material about human physiology can be taught in a more contextual manner.

Taxonomy of learning.The search results reveal that there are several types of learning taxonomies that researchers use as the HOTS concept they are researching. The taxonomies contained in the results of this study are Bloom's Taxonomy, Marzano's Taxonomy, and Gagne's Taxonomy. The difference from the three is shown in Table 7.

**Table 7**.
Differences in Bloom, Marzano, and Gagne's Taxonomy

	Bloom's Taxonomy	Marzano's Taxonomy	Gagne's Taxonomy
Dimensions	**2**	**2**	**1**
Dimension type	Knowledge dimension, Thinking process dimension	Knowledge dimension Processing level dimension	*Variety of Learning*
Focus	Cognitive Aspects	Cognitive, Affective, Psychomotor Aspects	Cognitive, Affective, Psychomotor Aspects
Position of Metacognition	As one part of the dimension of knowledge	As one of the stages of the thinking process	As one of the thinking process

Bloom's Taxonomy is more widely used in the world of education because of its great influence on curriculum development in the United States. Historically, Bloom's Taxonomy has been the basis of efforts to make the teaching and learning process more organized. In addition, Bloom's Taxonomy is also used to develop questions for national exams in the United States which began in the 1970s (Marzano & Kendall, 2007). Bloom's Taxonomy is also used in Indonesia as a curriculum reference. This refers to Permendikbud nomor 21 tahun 2016 about Standar Kompetensi Lulusan (Direktorat Jendral Guru dan Tenaga Kependidikan, 2020).

HOTS Research Trends.

Based on the analysis of the articles that have been carried out, it reveals HOTS research trends in high school learning on biology material, especially in Indonesia. Research trends began to increase since 2014 after the curriculum in Indonesia began implementing the 2013 Curriculum which promotes

HOTS-based learning for Indonesian students. HOTS research trends are presented in Figure 1. In addition, the learning model trend studied was dominated by the learning model suggested by the Ministry of Education and Culture to increase student HOTS (PBL, Inquiry learning, Discovery learning). Trends in the use of learning models are presented in Figure 2.
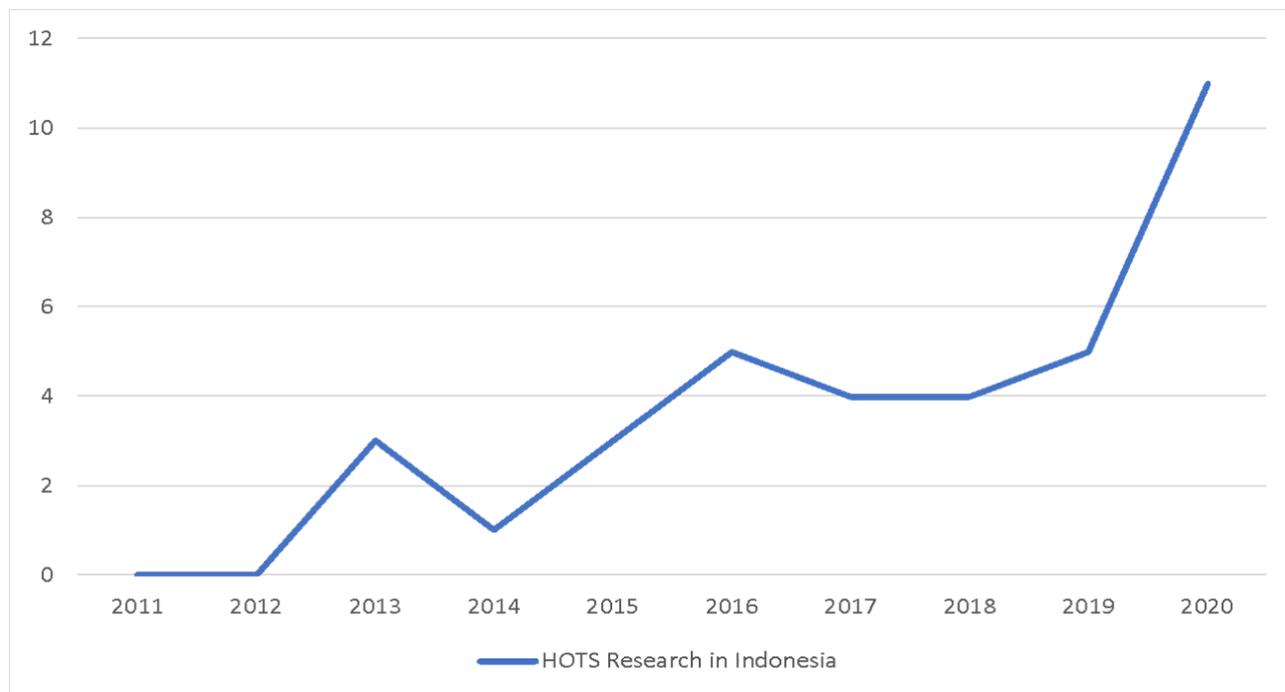
Figure 2. HOTS research in high school biology in Indonesia

Based on the data shows that the trend of the use of Higher Order Thinking (HOT) in Indonesia has increased for several reasons. According to Wardhani (2018), First, there are changes in the education curriculum that emphasizes the development of critical and creative thinking skills. Second, there is an increase in awareness about the importance of preparing students to succeed in the increasingly competitive world of work. Third, there is pressure from the business world and industry to produce graduates who are able to think critically and solve problems. Fourth, there is an increase in awareness about the importance of preparing students to become citizens who contribute to complex society.

CONCLUSION

Based on the results of the SR, the INSTAD model, and the PBI + STAD did not show an increase in students' higher order thinking skills. PBL, Inquiry, Discovery, Advance Organizer, Group Investigation, BBL, and POE models can improve higher-order thinking skills well. It can be concluded that constructivism-based learning is suitable for improving higher order thinking skills. In addition to the use of the learning models that have been mentioned, learning that uses learning in the laboratory, mixed methods, and the use of interactive multimedia can also improve higher-order thinking skills. Learning media to improve HOTS must be based on learning theory that helps students to learn actively, has appropriate illustrations, and a variety of materials. The instruments used in the 36 articles reviewed were instruments that were self-developed and validated by experts, as well as standardized instruments. The form of the instrument that was developed and validated in the form of description questions, multiple choice questions, open ended questions, and a mixture of several forms of questions. Questions to measure student HOTS generally attach an introduction material as material for students to think, use questions that are new and have never been taught in class, specifically for measuring high-level cognitive dimensions and do not have to have a high level of difficulty. The materials used in HOTS-based research are ecosystems, environmental pollution, human physiology, classification, cells, protists, fungi, and biotechnology. There are 3 types of taxonomies used in the 36 articles, namely Bloom's Taxonomy, Marzano's Taxonomy, and Gagne's Taxonomy, and the most adopted is Bloom's

Taxonomy because of its enormous influence in curriculum development in the United States. In addition, Bloom's Taxonomy is also a reference in developing SKL in the 2013 curriculum. HOTS research trends began to increase along with the implementation of the 2013 curriculum. HOTS research was conducted using the learning model suggested by the Ministry of Education and Culture and other models. The research results are expected to be used as a consideration for gap analysis in HOTS research, and the right efforts to improve students' HOTS in biology material. Future research can formulate effective learning methods, media, and assessment models for HOTS.

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Appendix 1. Reviewed Articles

Code	Article
N1	Wicaktini, A. (2017). *Pengaruh LKS Berbasis Problem Based Learning Terhadap Kemampuan Berpikir Tingkat Tinggi Siswa pada Konsep Sistem Pencernaan*. Skripsi. Universitas Islam Negeri Syarif Hidayatullah Jakarta.
N2	Achla, I. (2016). *Perbedaan Keterampilan Berpikir Tingkat Tinggi Antara Siswa yang Menggunakan Model Problem Based Learning dan Group Investigation*. Skripsi. Universitas Islam Negri Syarif Hidayatullah. Jakarta.
N3	Nurjannah, U., Prayitno, B. A., & Ariyanto, J. (2012). Pengaruh Pembelajaran Problem Based Instruction (PBI) Diintegrasikan dengan Student Team Achievement Division (STAD) Terhadap Kemampuan Berpikir Tingkat Tinggi dan Keerampilan Sosial. *Jurnal Pendidikan Biologi*, *4*, 12–21.
N4	Nurrachman, L. (2015). *Perbedaan Keterampilan Berpikir Tingkat Tinggi Antara Siswa Yang Menggunakan Model Pembelajaran Berbasis Masalah (Problem Based Learning) Dan Pembelajaran Berbasis Proyek (Project Based Learning) Pada Konsep Fungi*. Skripsi. Universitas Islam Negeri Syarif Hidayatullah Jakarta.
N5	Vasminingtya, D., Sajidan, S., & Fatmawati, U. (2014). Penerapan Model Pembelajaran Problem Based Learning dengan Memanfaatkan Potensi Lokal untuk Meningkatkan Aspek Problem Solving pada Higher-Order Thinking Skills. *Bio-Pedagogi*, *3*(2), 12–20.
N6	Kaniraras, D. A., Karyanto, P., & Kusumawati, L. (2015). Penerapan E-module Berbasis Problem-Based Learning untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi dan Mengurangi Miskonsepsi pada Materi Ekosistem Siswa Kelas X Sains 1 SMA Negeri 2 Karanganyar Tahun Pelajaran 2014/2015. *Proceeding Biology Education Conference*, *12*(1), 186–192. Surakarta.
N7	Azizah, A. N., & Prayitno, B. A. (2016). Penerapan Model Guided Inquiry Learning untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi Siswa Sma The Application of Guided Inquiry Learning Model to Improve Students ' High-Order Thinking Skill. *Bio-Pedagogi*, *8*, 39–43. Retrieved from http://eprints.unm.ac.id/16346/1/Artikel.pdf
N8	Ananda, B., & Prayitno, B. A. D. I. (2016). Penerapan Model Discovery Learning Pada Materi Ekosistem Untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi Siswa Kelas X Sma Implementing of Discovery Learning Model on Ecosystem Subject To Improve Higher Order Thinking Skill Students At Class X Ipa of. *Bio-Pedagogi*, *5*(1), 6–14.
N9	Noma, L. D., Prayitno, B. A., & Suwarno. (2016). PBL Untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi Siswa Kelas X SMA. *Bioedukasi*, *9*(2), 62–66. https://doi.org/10.1364/OL.36.003374
N10	Nur, M. (2012). *Penerapan Model Pebelajaran Tipe Group Investigation untuk Meningkatkan Partisipasi dan Kemampuan Berpikir Tingkat Tinggi Siswa Kelas X-9 SMA Batik 1 Surakarta*.Skripsi. Universitas Sebelas Maret.
N11	Evi Nur, Q., Karyanto, P., & Sugiharto, B. (2012). The Influence of INSTAD Learning Strategies Toward Students High Order Thingking Skills In Studying Biology. *Bio-Pedagogi*, *1*(1), 46–53.
N12	Riandari, F., Susanti, R., & Suratmi. (2018). The influence of discovery learning model application to the higher order thinking skills student of Srijaya Negara Senior High School Palembang on the animal kingdom subject matter. *International Conference of Science, Mathematics, Environment, and Education*, *1022*(1). https://doi.org/10.1088/1742-6596/1022/1/012055
N13	Asma. (2014). *Peningkatan Keterampilan Berpikir Tingkat Tinggi Peserta Didik Menurut Revisi Taksonomi Bloom melalui Penerapan Problem Based Learning pada Materi Bioteknologi Kelas XII SMA.* Skripsi. Universitas Sebelas Maret. https://doi.org/10.1017/CBO9781107415324.004
N14	Ramdiah, S., Abidinsyah, H., Mayasari, R., Education, B., Program, S., & Kalimantan, S. (2018). Problem-Based Learning: Generates Higher-Order Thinking Skills of Tenth Graders in Ecosystem Concept. *Jurnal Pendidikan Biologi Indonesia*, *4*(1), 29–34.
N15	Magdalena, R. (2016). Penerapan Model Pembelajaran Problem Based Learning (PBL) serta Pengaruhnya terhadap Hasil Belajar Biologi Siswa SMA Negeri 5 Kelas XI Kota Samarinda Tahun Ajaran 2015. *Proceeding Biology Education Conference*, Surakarta. *13*(1), 299–306. Retrieved from https://jurnal.uns.ac.id/prosbi/article/view/5728
N16	Karmana, I. W. (2013). Memberdayakan Berpikir Tingkat Tinggi (Higher Order Thinking) Siswa SMA dalam Pembelajaran Biologi. *Jurnal Prima Sains*, 37–39.
N17	Yuda, D. A. (2019). Penerapan Model Pembelajaran Advance Organizer untuk Meningkatkan Kemampuan Berpikir Tingkat Tinggi(HIGH ORDER THINKING SKILLS) Siswa pada Mata Pelajaran Biologi Kelas XI di SMA Negeri 11 Bandung. *Edutechnologia*, *3*(1), 1–10.
N18	Suryamiati, W., Kahar, A. P., & Setiadi, A. E. (2019). Improving higher-order thingking skill through POE (Predict, Observe, Explain) and guided discovery learning models. *Jurnal Pendidikan Biologi Indonesia*, *5*(2), 245–252. https://doi.org/10.22219/jpbi.v5i2.8266
N19	Alfiani, M. (2018). *Perbedaan Keterampilan Berpikir Tingkat Tinggi antara Siswa yang Menggunakan Model Inkuiri Terbimbing dan Inkuiri Bebas pada Konsep Peredaran Darah Manusia*. Skripsi. Universitas

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N20	Linda, T. (2018). Pengaruh Penerapan Model Pembelajaran Discovery Learning Terhadap Kemampuan Siswa Menyelesaikan Soal-Soal Biologi Berkategori HOTS di SMA Negeri 1 Tana Toraja The Effect of Application of Discovery Learning Learning Model on Students ' Ability to Complete. *Prosiding Seminar Nasional Biologi VI*, 771–778. Makassar Retrieved from https://ojs.unm.ac.id/semnasbio/article/download/10649/6262
N21	Yulita, E. (2018). *Efektivitas Pembelajaran Berbasis Masalah Pencemaran Limbah Cairan Pemutih dalam Meningkatkan Keterampilan Berpikir Tingkat Tinggi.* Skripsi. Universitas Lampung. Retrieved from https://movisa.org.mx/images/NoBS_Report.pdf
N22	Nabilah, S., Anwar, Y., & Riyanto, R. (2019). Motoric mechanism with problem based learning: impact on students' higher order thinking skill. *Biosfer*, *12*(2), 182–193. https://doi.org/10.21009/biosferjpb.v12n2.182-193
N23	Fitriani, D., Jalmo, T., & Yolida, B. (2019). Penggunaan Problem Based Learning untuk Meningkatkan Keterampilan Kolaborasi dan Berpikir Tingkat Tinggi. *Jurnal Bioterdidik*, *7*(2), 35–45. Retrieved from http://jurnal.fkip.unila.ac.i255d/index.php/JBT/article/view/17
N24	Aspridaniel, A., Jalmo, T., & Yolida, B. (2019). Penggunaan Problem Based Learning dalam Meningkatkan Keterampilan Kolaborasi dan Berpikir Tingkat Tinggi. *Jurnal Bioterdidik*, *7*(2), 35–45. Retrieved from http://jurnal.fkip.unila.ac.i255d/index.php/JBT/article/view/17
N25	Zulfiani, Z., Yunistika, R., & Juanengsih, N. (2018). Enhancing Students Higher-Order Thinking Skills Through Guided and Free Inquiry-Based Learning. *Advances in Social Science, Education, and Humanities Research*, *115*, 28–31. https://doi.org/10.2991/icems-17.2018.6
N26	Atikah, N., Djulia, E., & Silitonga, M. (2018). The Effects of Guided Inquiry and Modified Free Inquiry Learning Models on Students' Higher Order Thinking Skills for the Topic of Human Respiratory System at SMA Negeri 1 Labuhan Deli. *3rd Annual International Seminar on Transformative Education and Educational Leadership*, *200*, 828–831. https://doi.org/10.2991/aisteel-18.2018.180
N27	Afcariono, M. (2008). Penerapan Pembelajaran Berbasis Masalah untuk Meningkatkan Kemampuan Berpikir Siswa pada Mata Pelajaran Biologi. *Jurnal Pendidikan Inovatif*, *3*(Nomor 2), 65–68. https://doi.org/10.1039/c5cp04034e
N28	Suwono, H., & Dewi, E. K. (2019). Problem-based learning blended with online interaction to improve motivation, scientific communication and higher order thinking skills of high school students. *AIP Conference Proceedings*, *2081*. Bangkok https://doi.org/10.1063/1.5094001
N29	Novita Adiqka, P., Nurwidodo, & Yuni, P. (2015). Perbedaan Model Pembelajaran Open Inquiry Dan Guided Inquiry Berdasarkan Kemandirian Belajar Dan Berfikir Tingkat Tinggi Pada Mata Pelajaran Biologi Kelas 11 Man Tempursari – Ngawi. *Jurnal Pendidikan Biologi Indonesia*, *1*(1). https://doi.org/10.22219/jpbi.v1i1.2300
N30	Az-zahra, W., & Arsal, A. F. (2019). *Kemampuan Berpikir Tingkat Tinggi Peserta Didik Yang Dibelajarkan Dengan Model Problem-Based Learning Pada Pembelajar Biologi Di Sekolah Menengah Atas*. Skripsi. Universitas Negeri Makassar.
N31	Hermala. (2019). *Pengaruh Model Pembelajaran Brain Based Learning Terhadap Kemampuan Berpikir Tingkat Tinggi Pada Materi Biologi Ditinjau dari Motivasi Belajar Peserta Didik Kelas X SMA Negeri 8 Bandar Lampung*. Skripsi.Univesitas Lampung.
N32	Sulastri. (2014). Perbandingan Kemampuan Berpikir Tingkat Tinggi Antara Penerapan Model Discovery Learning dengan Memanfaatkan Potensi Ekosistem Pesisir dan Pembelajaran Konvensional pada Siswa Kelas X SMA N 1 Tanjungsari. *Seminar Nasional Pendidikan Biologi FKIP UNS*. Surakarta.
I1	Ali, A., Islamiah, D., & Zulkifli, Z. (2019). The Effectiveness of Problem - Based Learning Methods in Improving High-Order Thinking Skills. *International Conference on Mechanical and Manufacturing Engineering*, *1150*(1). https://doi.org/10.1088/1742-6596/1150/1/012065
I2	Lee, T. J., Nurzatulshima Kamarudin, Aminuddin Hassan, & Othman Talib. (2014). Inquiry-based learning in laboratory Science. *Man In India*, *97*(December 2014), 185–194.
I3	Mehmood, N., Anwer, M., & Tatlah, I. A. (2017). Effect of Combined Teaching Strategies on Higher Order Thinking Skills (HOTS) of Biology Students. *Global Regional Review*, *II*(I), 389–404. https://doi.org/10.31703/grr.2017(ii-i).28
I4	Sabu, N. (2018). The Effect of using Interactive Multimedia Courseware with Pedagogical Agent in Learning Nutrition towards Higher Order Thinking Skills. *International Journal of Academic Research in Business and Social Sciences*, *8*(2). https://doi.org/10.6007/ijarbss/v8-i2/3971