UNIVERSITAS SEBELAS MARET
BIOEDUKASI: JURNAL PENDIDIKAN BIOLOGI
https://jurnal.uns.ac.id/bioedukasi/
1693-265X (Print) | 2549-0605 (Online)

The Trend of Critical Thinking Studies in Biology Education through Online Learning: A Systematic Review

Ayu Rahma Ulufa Nuri [a, 1], **Sajidan** [a, 2], **Murni Ramli** [a, 3,*]

[a]Department of Biology Education, Postgraduate Program, Universitas Sebelas Maret, Surakarta
[1] ayurahma7@student.uns.ac.id; sajidan@fkip.uns.ac.id; mramlim@staff.uns.ac.id*
* Corresponding author

Submission : 16/06/2021
Revision : 30/07/2021
Accepted : 31/08/2021

ABSTRACT

Biology teachers and students in society 5.0 are expected to show critical thinking skills (CTS) in solving problems or making decisions. Thus, it is important to know how the CTS are nurtured through online learning. The trend of studies on these issues needs to be explored. This research aims to map the trend of studies on nurturing the CTS through online learning by reviewing some articles published within 2018-2020, considering 1) the online learning, 3) topics in biology, 4) teaching methods, and 5) instruments of CTS. Following the systematic review of the PRISMA Method, articles were screened from Google Scholar. The keywords were "critical thinking", "biology education", "online learning", and "Indonesia", which resulted in 23 articles to be further reviewed. The findings show that CTS's research trends using online learning have increased due to the COVID-19 pandemic that requires students and teachers to distance studies. The most used online learning was digital learning. The researchers used various topics in biology to measure students' CTS using online learning but mainly genetics and cell biology. The most widely used teaching method is blended learning and online discussion which various learning models can combine learning methods or learning media. The test is mainly used as an instrument to measure CTS with various indicators presented by experts. Research on CTS using online learning needs to be further explored to increase the quality of the study.

Keywords: A Systematic Review, Biology Education, Critical Thinking, , Online Learning,

Introduction

The 21st century is marked as the era of Society 5.0, where information and technology are spreading and developing very rapidly. It's no wonder that experts categorize the 21st century as a century of knowledge. In this century, knowledge intertwines and synergies quickly, which requires everyone to adapt and compete in education and work. Higher Order Thinking Skills (HOTs) are essential in the face of intense competition in this knowledge age. The logical consequence is that the existence of human resources becomes a complete device that has intelligence and mastery of knowledge and equips itself with HOTs. CTS is one of the HOTs needed to deal with the increasing rate of change, complexity, and interdependence in the 21st century (Ben-chaim, Ron, & Zoller, 2000; Dwyer, Hogan, & Stewart, 2014). This skill is also a metacognition process and includes high-level cognitive skills (Abrami et al., 2008; Ben-chaim et al., 2000; Dwyer, Hogan, Harney, & Kavanagh, 2017; Noone & Hogan, 2017). Partnership for 21st Century Skills (P21), Assessment and Teaching 21st Century Skills (ATC-21S), and Indonesian Partnership for 21st Century Skills Standards (IP-21CSS) state that CTS is one of the skills needed in this century. CTS is important to be trained for students compared to other HOTs skills because other 21st century skills involve CTS so that CTS is the essential skill among other 21st century skills. One of the 21st century skills is 4C, namely CTS and problem solving skills, creative thinking and innovation skills, communication skills, and collaborative skills (Buchert, 2014; Fong, Sidhu, & Fook, 2014, Kivunja, 2014; Marope, 2015).
Education can accommodate demands for the intellectual ability of students to think smartly and selectively in choosing valid and relevant information. It can train students' cognitive, affective, and psychomotor skills to form a character that will affect students' attitudes in life (Kozleski, Yu, Satter, Francis, & Haines, 2015). Education can train people to have HOTs (Angeli & Valanides, 2009; Ben-chaim et al., 2000; Zenker, 2016). CTS has been widely studied in education and other fields of natural science such as biology, physics, chemistry, economics, environmental sciences, and art (Islek & Hursen, 2014; Nuri, Sajidan, Oetomo, Prasetyanti, & Parmin, 2019). Entering Society 5.0, teachers and students are required to master digital learning, such as online learning. Online learning is a method for teaching and learning connected to the internet, increasing student motivation and attention and increasing the effectiveness and efficiency of information delivery. Learning media is important to help students in the learning process. Online learning was developed as an open access learning method which expected to attract the attention of students, provide motivation to students, therefore information conveyed through the media can be captured by students and tested on teaching and learning to see the practicality of using the online learning. Online learning has the scope of administration, delivery of material, assessment, monitoring, and communication. Materials in pedagogical and professional competencies, which are made with multimedia packaging (text, animation, video, and sound) in the online learning will accelerate the mastery of science and technology that can improve the quality of learning (Alfianto & Karyanto, 2019). There are many studies show that online learning media are successfully used as a learning environment. Therefore, online learning attracted a lot of attention from educators, and they started trying to find out how online learning could be used in educational settings to aid their teaching (Durak, 2017).

The 21st century assessment must teach students to apply CTS (Binkley et al., 2012). CTS needs to be developed and trained for students to practice high-level thinking habits, decision-making by scientific truth, problem solving, and improvement in learning outcomes (Suyanto, Susanto, & Linuwih, 2012; Zhang et al., 2017; ŽivkoviÜ, 2016). The success or failure of education depends on the learning process experienced by students (Siti Rahmah dan Muhammad Kusas, 2016). According to the importance of CTS and Society 5.0, students must be equipped with the knowledge to produce CTS, produce works to compete in the

international world (Nuri et al., 2019), and mastery of digital learning media. Therefore, the purpose of this study is to identify the trends of CTS research in biology education through online learning from 2018 to 2020, including 1) the publication year, 2) online learning media, 3) topics in biology, 4) teaching methods, and 5) instruments of CTS.

Methods

The method used in this study is a systematic review with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyzes). PRISMA is a guideline to assist researchers in preparing data search protocols presented in systematic reviews. This guideline contains protocols for reviewing articles to ensure accurate and comprehensive results under the research objectives. Components in PRISMA include identification, screening, and eligibility (FIGURE 1) (Liberati et al., 2009; Moher, Liberati, Tetzlaff, & Altman, 2009). Researchers obtained the articles from Google Scholar and limited them from 2018 to 2020. The determination of the year is based on previous systematic review studies that have examined CTS in biology education in 2010-2017 (Susetyarini & Fauzi, 2020) and previous systematic review studies on biology studies in Indonesia in 2012-2017 (Haviz & Ridho, 2019), so this research continues the previous research by adding the keywords "online learning". The keywords used in this study were "critical thinking", "biology education", "online learning", and "Indonesia". The PRISMA method is produced 23 articles related to the keywords. Inclusion and exclusion criteria are included in this study to find the relevant articles (TABLE 1).

TABLE 1. A Criterion of inclusion and exclusion articles

Criterion	Inclusion	Exclusion
Publication Year	2018 to 2020	Articles outside these years
Country	Indonesia	Articles outside Indonesia
Sample group	University student, senior high school (SHS), and junior high school (JHS)	Articles outside these criteria including elementary, kindergarten, and early childhood
Language	English and Indonesian Language	Articles outside these criteria
Study focus	Biology education, CTS, online learning	Articles outside these criteria
Type of article	Qualitative, quantitative, mix method, R&D, CAR	Articles outside these criteria, including systematic review, literature review, etc.
Database	Google Scholar	Articles outside these criteria

The researchers used the Microsoft Access program to analyze the data. It was used to save the defined criteria and to create a database. We kept all the data obtained from the detailed analysis of the documents for each article. The reports were made by grouping the data according to the defined criteria using the questioning features.

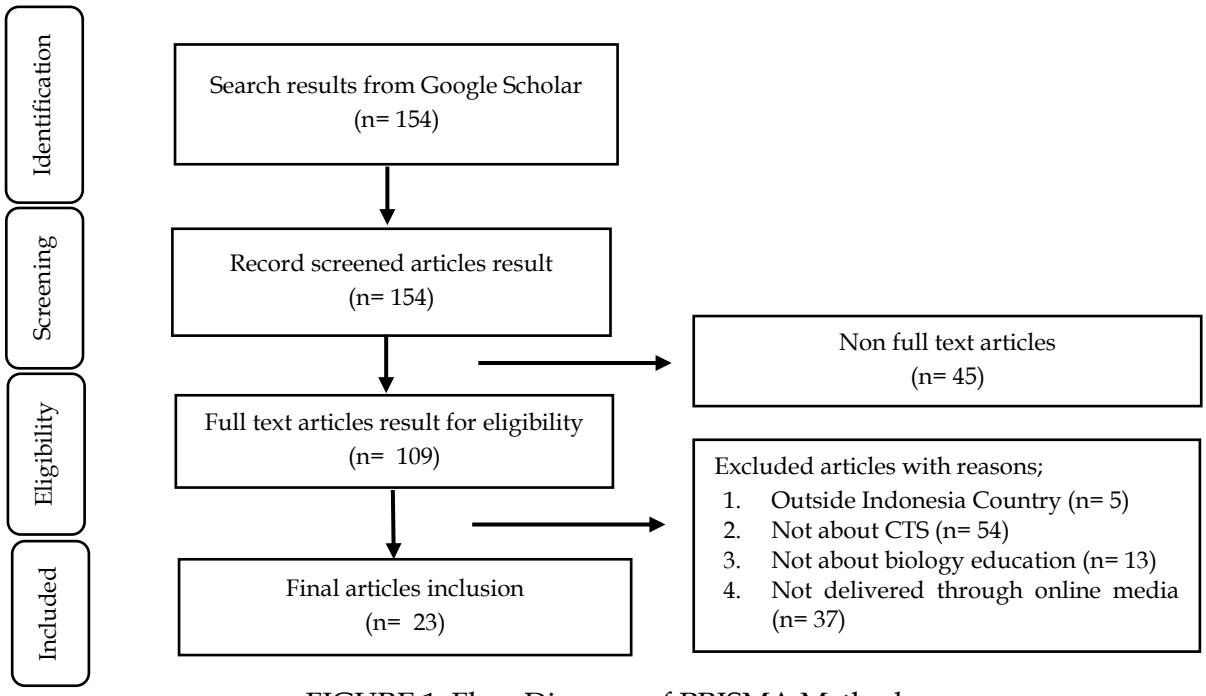

FIGURE 1. Flow Diagram of PRISMA Method

Result and Discussion

Entering the era of Society 5.0, all sectors of life lead to digitalization, including the education sector. Education must be able to adapt to all current progress. Online learning is one of the systems that began to develop among academics to convey the learning process. However, CTS is one of the skills that remain the focus of research because this skill is the basis of HOTS. In this section, we present our findings to find out trends in research on CTS using online learning, which is restricted from 2018 to 2020 and produced 23 articles.

Publication Year

The articles on CTS and online learning from 2018 to 2020 are various (FIGURE 2). In 2018, there were only two articles, and in the year 2019, there were ten articles related to the keywords. 2020 was the peak year of research on CTS associated with online learning, which produced eleven articles. In 2020, the number of article publications on CTS using online learning had grown due to the COVID-19 pandemic conditions that require students and teachers to do distance studies. Researchers must be productive in producing articles related to HOTs to be trained on students, especially CTS. The published articles can be used as references by teachers to teach CTS in the pandemic era.

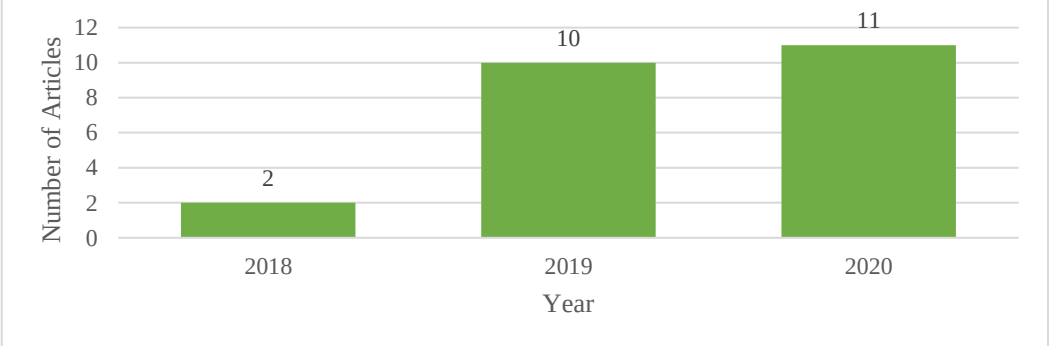

FIGURE 2. Publication Year of The Studies

Online learning media

Online learning is a method to distribute the subject matter and enable collaboration between students and teachers. Online learning allows teachers to receive assignments digitally and stay in touch with their students (Anggriawan, 2009). Online learning can use Edmodo, Google Classroom, Web, WhatsApp, Digital Learning, Google Meet, Zoom, and Gen21-cs (FIGURE 3). Four researchers use Edmodo, Google Classroom is used by two researchers, the web-based is used by five researchers, WhatsApp is used by three researchers, Digital Learning is used by seven researchers, and gen21-cs is used by two researchers. In comparison, one researcher per each uses Google Meet, Zoom, and Virtual lab. Gen21-cs is only used for genetic topics, and the same researcher makes this application. The use of a smartphone, digital media, and multimedia learning is included in the digital learning group.

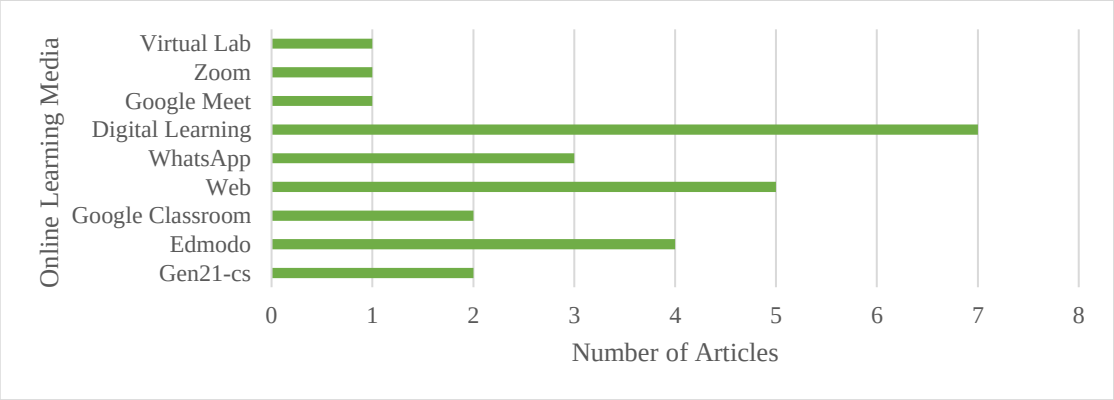

FIGURE 3. Online Learning Media

The web is a tool through which learning activities and learning resources can be accessed (Petchtone & Sumalee, 2014). The web is used in web-based learning that can be combined with other learning techniques to enhance students' HOTs. One example of web-based learning is a web quest that requires scaffolding techniques where students get guidance from the teacher to achieve learning objectives. Web-based learning requires high motivation from students to solve the problems presented in education (Hidayah, Lumowa, & Boleng, 2018). Motivated students will influence the filtering of information and concluding. Furthermore, to improve CTS, web quest requires collaborative learning where students must work together to complete a project to reach the learning objectives (Averkieva, Chayka, & Glushkov, 2015). Based on the analysis, web-based learning combined with scaffolding and collaborative learning techniques can enhance students' CTS (Tiruneh, Verburgh, & Elen, 2014).

According to Xu (2016), the learning content must be sequenced to support students' deep understanding of CTS through online learning. This sequence can be based on the stage of student development, and the grade level studied based on a logical analysis (Plummer & Maynard, 2014; Shavelson, 2012) found in Learning Progression (LP). LP develops students' potential to move towards a deeper understanding of the big ideas of science in a long period (Smith, Wiser, Anderson, & Krajcik, 2006). Shavelson (2012) states that learning progression is a sequence of more complex ways of reasoning about a series of ideas from simple to complex; it relies on instructions that interact with previous knowledge and construction of new knowledge to develop from beginners to beginners experts. Therefore, further research is needed on LP to improve student CTS using online learning media.

Google Classroom is part of G-Suite for Education which is bound with Drive, Hangouts Meet, Calendars, Forms, Docs, Slides, Sheets, and G-mail, which means these services can be utilized in the learning process (Ventayen, Estira, Guzman, Cabaluna, & Espinosa, 2018). It enables teaching and learning activities to be more productive and meaningful by simplifying assignments, increasing collaboration, fostering communication, and free access. Teachers can create classes, share materials, give tasks, send feedback, quickly see who has and hasn't completed a task, and immediately provide real-time grades and input. Students can view tasks on the assignments page, in the class stream, or on the calendar. They can share material and interact in the class stream or via email. All class material is automatically stored in the Google Drive folder.

Edmodo is a social networking learning platform aimed at teachers, students, and even parents of students. This social media benefits learning activities, providing a safe and easy way to create virtual classes based on class divisions such as at school (Durak, 2017). Some features in Edmodo are; a) Assignment, i.e., pages for assigning and uploading assignments. b) Gradebook, i.e., a page for giving grades to students. c) Polling, i.e., a page to check student activities. d) Quiz, i.e., a page for assessing students. e) Library, i.e., a page to provide learning material for students. f) Parents code, i.e., a page for students' parents in monitoring student learning activities (F. Dewi, 2014). Teachers and parents can see everything posted on it; therefore, cyberbullying and inappropriate content can be prevented (Cauley, 2013). Future studies are suggested to examine CTS in biology using online learning that has never been used before. Furthermore, researchers can develop online learning media that is appropriate to the characteristics of biology learning.

Topics in Biology

Biology is a discipline that has many topics that must be taught and mastered by students (FIGURE 4). Based on the results of a systematic review, many biology topics are used in research. Topics that have been studied in 1) JHS are human physiology and life organizational system, 2) SHS are bacteria, digestive system, environment, human physiology, and excretory system, and 3) the university is genetic, cell biology, histology, nonvascular plant, anatomy & physiology of human, animal, and plant, reproduction system and research. Researchers can use all topics using online learning in CTS research. The results of a systematic review show that topics in biology are thoroughly researched. However, some topics that are widely researched, although not significant, are cell biology and genetics. Future studies are suggested to examine the topic of biology, which is less researched using online learning to enhance students' CTS.

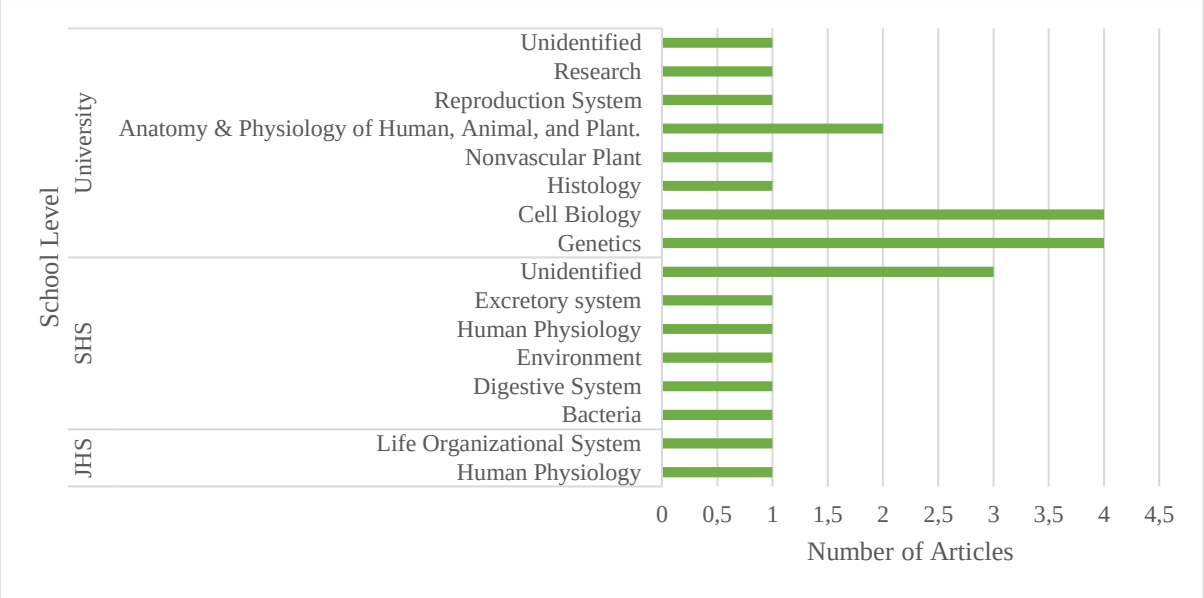

FIGURE 4. Biology Topic in Each Level

Teaching Methods

The teaching methods that are widely used are blended learning and online discussion. The blended learning approach combines synchronous and asynchronous activities (Limiansi, Tias, & Devi, 2020). The blended learning approach can be combined with various learning models, learning methods, or learning media, such as the PDEODE-WEB model (Mailani, Zulfarina, & Syafii, 2020), Tri Hita Karana (THK) Device (N. P. S. R. Dewi, Adnyana, & Citrawathi, 2020), guided discovery (Suparini, Rusdi, & Ristanto, 2020), Project-based Learning (Permana & Chamisijatin, 2019; Putri & Hendawati, 2018), Problem-based Learning (Lukitasari, Purnamasari, Utami, & Sukri, 2019), and Edmodo-based blended learning model (Wahyuni, Gusti Made Sanjaya, Erman, & Jatmiko, 2019). Researchers most widely use the blended learning approach to connect various learning media such as real-time virtual classrooms and face-to-face classrooms using videos, pictures, etc. Online discussion is the second option in online learning. This method allows discussion members to improve their CTS. Online discussions can be combined with the PBL model (Y. Maryuningsih, Hidayat, Riandi, & Rustaman, 2019; Yuyun Maryuningsih, Hidayat, Riandi, & Rustaman, 2020), social media (Y. Maryuningsih, Hidayat, Riandi, & Rustaman, 2020), multimedia such as Virtual Class (Rakhmawati, Hasnunidah, & Priadi, 2020), and Open Educational Resources (Rahayu & Sapriati, 2018). The other teaching methods used are the anchored instruction model, PBL, elaboration model, BTEM-based web, argument-driven inquiry model, STEM, life-based learning, and guided discovery learning that can enhance students'CTS. The result can be seen in (FIGURE 5).

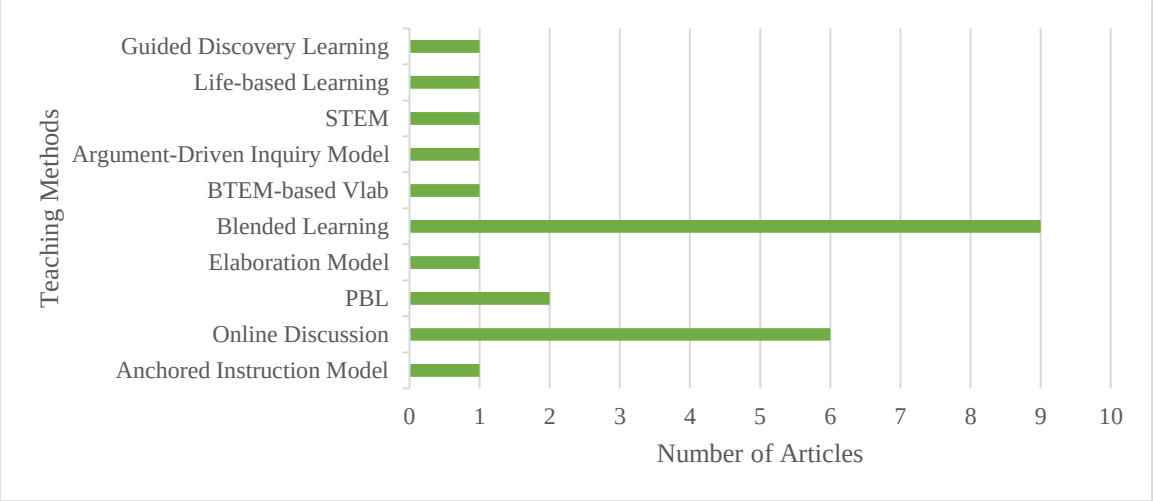

FIGURE 5. Teaching Methods

Instruments

CTS instruments used in the studies are various, namely observation, questionnaire, test, interview, and document analysis (FIGURE 6). Researchers found the observation method in nine articles, the questionnaire method in eleven articles, the test method in seventeen articles, the interview method in four articles, and the document analysis method in three articles. The most widely used method is the test method as the core method in measuring student CTS. Other data gathering methods, such as interviews, questionnaires, and observations, are additional data collection tools.

The test instrument can be a multiple-choice, essay, open-ended question, and closed question. It is made based on indicators of critical thinking skills presented by experts. Rahayu & Sapriati (2018) use the CTS indicator from Ennis, which consists of building basic skills, providing a simple explanation, asking and answering questions, and setting strategies and tactics, resulting in a score of 80,7 (Rahayu & Sapriati, 2018). This finding is also done by Putri & Hendawati (2018). They use the CTS indicator from Ennis, which consists of defining terminology, focusing on questions, analyzing arguments, understanding and using graphs or mathematical concepts, completing and taking into account an assumption, and using ready knowledge. The result states that the analyzing arguments indicator gets the highest score in the high category. The focusing on questions indicator gets a low category, while the other indicators get the moderate category (Putri & Hendawati, 2018). Lukitasari et al. (2019) also use the CTS indicator from Ennis, which consists of providing a simple explanation, developing basic skills, drawing conclusions, providing a further explanation, and setting strategies and tactics (Lukitasari, Purnamasari, et al., 2019). In the same year, Lukitasari et al. (2019) used the CTS indicator from Avierkieva (2015) and Arifin (2012), which consisted of grammar, completeness, the consistency of information presented, creativity, defining, and developing information (Lukitasari, Hasan, & Murtafiah, 2019). In contrast to Maryuningsih (2019), who uses the CTS indicator from Facione, which consists of interpretations, analyzes, evaluations, inferences, and explanations that produce a score of 57.49.

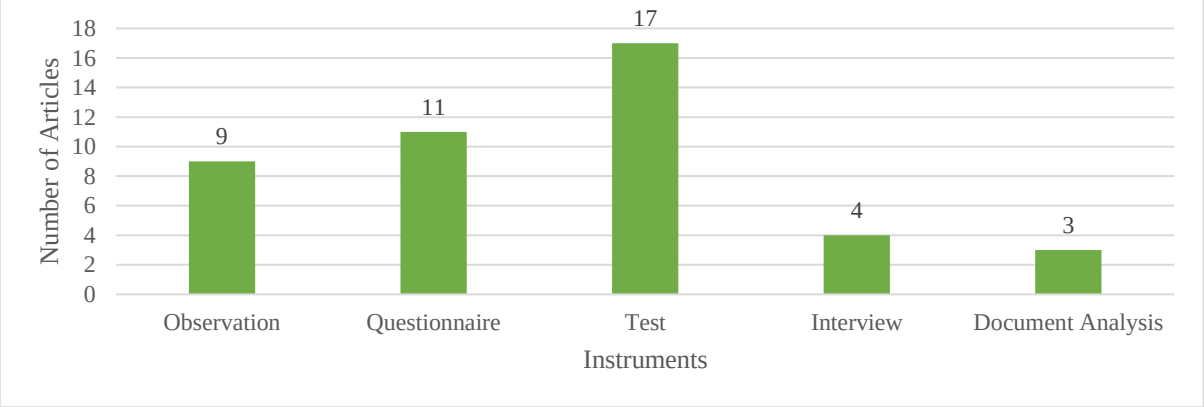

FIGURE 6. Instruments of CTS

Conclusion

Teachers need to train students with CTS to deal with the increasing rate of change, complexity, and interdependence in the 21st century. Research trends on CTS using online learning from 2018 to 2020 have increased due to the COVID-19 pandemic conditions that require students and teachers to distance studies. The researchers used digital learning and various biology topics to measure students' CTS using online learning but mostly are genetics and cell biology. The most widely used teaching method is blended learning and online discussion. The researchers can be combining with various learning models, learning methods, or learning media. The test is mainly used as an instrument to measure CTS with various indicators presented by experts. The Research on CTS using online learning needs to be further explored to increase the quality of research.

Acknowledgement

The research is sponsored by the research grant from BRIN RISTEK (Ministry of Education, Culture, Research, and Technology) of Indonesia, FY 2021/2022, led by Murni Ramli. The contract number is 221.1/UN27.22/HK.07.00/2021.

References

Abrami, P. C., Bernard, R. M., Borokhovski, E., Wade, A., Michael, A., Meta-analysis, A. S., … Zhang, D. (2008). Instructional

Interventions Affecting Critical Thinking Skills and Dispositions: A Stage 1 Meta-Analysis. *Journal of Educational Research*, *78*, 1102. https://doi.org/10.3102/0034654308326084

Alfianto, A. B., & Karyanto, P. (2019). Learning management system for eco literacy enhancement : The effectiveness of adopting Lewinshon indicators as an additional standard of competence Learning Management System for Eco Literacy Enhancement : The Effectiveness of Adopting Lewinshon Indicato. *AIP Conference Proceeding*, *020002*, 2194.

Angeli, C., & Valanides, N. (2009). Instructional Effects on Critical Thinking : Performance on Ill-defined Issues. *Learning and Instruction*, *19*(4), 322–334. https://doi.org/10.1016/j.learninstruc.2008.06.010

Anggriawan, F. S. (2009). Pengembangan Learning Management System (LMS) Sebagai Media Pembelajaran Untuk Sekolah Menengah, (ellis), 1–10.

Averkieva, L., Chayka, Y., & Glushkov, S. (2015). Web Quest as a Tool for Increasing Students' Motivation and Critical Thinking Development. *Procedia - Social and Behavioral Sciences*, *206*(November), 137–140. https://doi.org/10.1016/j.sbspro.2015.10.042

Ben-chaim, D., Ron, S., & Zoller, U. (2000). The Disposition of Eleventh-Grade Science Students Toward Critical Thinking. *Journal of Science and Education*, *9*(2).

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-ricci, M., & Rumble, M. (2012). Defining Twenty-First Century Skills. *Springer Science and Business*, 17–66. https://doi.org/10.1007/978-94-007-2324-5

Buchert, L. (2014). Learning Needs and Life Skills for Youth : An Introduction. *Journal of Rev Education*, (123), 163–176. https://doi.org/10.1007/s11159-014-9431-3

Cauley, P. (2013). *A guide to explain it all*.

Dewi, F. (2014). Edmodo : A Social learning platform for blended learning class in higher education. *Researc in Education Technology : Pedadogy and Technology Journal.SEAMEO-SEAMOLEC*, *XI*(2), 1–11.

Dewi, N. P. S. R., Adnyana, P. B., & Citrawathi, D. M. (2020). The Validity of Tri Hita Karana (THK) Oriented Blended Learning Tools to Improve Student's Critical Thinking Ability. *Journal of Physics: Conference Series*, *1503*(1). https://doi.org/10.1088/1742-6596/1503/1/012052

Durak, G. (2017). International Review of Research in Open and Distributed Learning Using Social Learning Networks (SLNs) in Higher Education: Edmodo Through the Lenses of Academics. *International Review of Research in Open and Distributed Learning*, *18*(1), 85–109.

Dwyer, C. P., Hogan, M. J., Harney, O. M., & Kavanagh, C. (2017). Facilitating a student-educator conceptual model of dispositions towards critical thinking through interactive management. *Educational Technology Research and Development*, *65*(1), 47–73. https://doi.org/10.1007/s11423-016-9460-7

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2014). An Integrated Critical Thinking Framework for The 21st Century. *Thingking Skill and Creativity*, *12*, 43–52.

Fong, L. L., Sidhu, G. K., & Fook, C. Y. (2014). Exploring 21st century skills among postgraduates in Malaysia. *Procedia - Social and Behavioral Sciences*, *123*, 130–138. https://doi.org/10.1016/j.sbspro.2014.01.1406

Haviz, M., & Ridho, M. (2019). Trend in Biology Education Research From 2012 To 2017: a Content Analysis of Papers in Selected Journals From Indonesia. *Edusains*, *11*(2), 221–232. https://doi.org/10.15408/es.v11i2.10466

Hidayah, M. U., Lumowa, S. V. T., & Boleng, D. T. (2018). Developing The Archaebacteria and Eubacteria Web-based Learning Media for High School Students. *Jurnal Pendidikan Biologi Indonesia*, *4*(2), 179–188.

Islek, D., & Hursen, C. (2014). Evaluation of Critical Thinking Studies In Terms of Content Analysis. *Journal of Social and Behavioral Sciences*, *131*, 290–299. https://doi.org/10.1016/j.sbspro.2014.04.119

Kivunja, C. (2014). Do You Want Your Students to Be Job-Ready with 21 st Century Skills ? Change Pedagogies : A Pedagogical Paradigm Shift from Vygotskyian Social Constructivism to Critical Thinking , Problem Solving and Siemens ' Digital Connectivism. *International Journal of Higher Education*, *3*(3), 81–91. https://doi.org/10.5430/ijhe.v3n3p81

Kozleski, E. B., Yu, T., Satter, A. L., Francis, G. L., & Haines, S. J. (2015). A Never Ending Journey: Inclusive Education Is a Principle of Practice, Not an End Game. *Research and Practice for Persons with Severe Disabilities*, *40*(3), 211–226. https://doi.org/10.1177/1540796915600717

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., … Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Medicine*, *6*(7).

https://doi.org/10.1371/journal.pmed.1000100

Limiansi, K., Tias, A., & Devi, R. (2020). Transformation in Biology Learning during the Covid-19 Pandemic : From Offline to Online, *9*, 189–202.

Lukitasari, M., Hasan, R., & Murtafiah, W. (2019). Using critical analysis to develop metacognitive ability and critical thinking skills in biology. *Jurnal Pendidikan Biologi Indonesia*, *5*(1), 151–158. https://doi.org/10.22219/jpbi.v5i1.7262

Lukitasari, M., Purnamasari, I., Utami, S., & Sukri, A. (2019). Blended-Problem-Based Learning: How its impact on students' critical thinking skills? *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *5*(3), 425–434. https://doi.org/10.22219/jpbi.v5i3.10048

Mailani, T., Zulfarina, & Syafii, W. (2020). Development of the PDEODE-WEB Model in Blended Learning to Improve the Students Critical Thinking Skills. *Journal of Physics: Conference Series*, *1655*(1). https://doi.org/10.1088/1742-6596/1655/1/012054

Marope, P. T. M. (2015). Learning and Competences for The 21 Century. *Journal of Prospect*, *44*(2014), 483–486. https://doi.org/10.1007/s11125-014-9333-y

Maryuningsih, Y., Hidayat, T., Riandi, R., & Rustaman, N. Y. (2019). Critical thinking skills of prospective biology teacher on the chromosomal basic of inheritance learning through online discussion forums. *Journal of Physics: Conference Series*, *1157*(2). https://doi.org/10.1088/1742-6596/1157/2/022090

Maryuningsih, Y., Hidayat, T., Riandi, R., & Rustaman, N. Y. (2020). Contribution of internet resources to mastery genetic concept on prospective teachers. *Journal of Physics: Conference Series*, *1521*(4). https://doi.org/10.1088/1742-6596/1521/4/042010

Maryuningsih, Yuyun, Hidayat, T., Riandi, R., & Rustaman, N. Y. (2020). The critical thinking skills of biology teacher candidates toward the ethical issues. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *6*(1), 65–74. https://doi.org/10.22219/jpbi.v6i1.10779

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Physical Therapy*, *89*(9), 873–880.

Noone, C., & Hogan, M. J. (2017). Improvements in Critical Thinking Performance Following Mindfulness Meditation Depend on Thinking Dispositions. *Journal of Mindfulness*. https://doi.org/10.1007/s12671-017-0789-8

Nuri, A. R. U., Sajidan, Oetomo, D., Prasetyanti, N. M., & Parmin. (2019). Improving Indonesian Senior High School Students ' Critical Thinking Skill through Science Integrated Learning (SIL) Model. *Journal of Education and Teacher Training*, *4*(2), 145–158. https://doi.org/10.24042/tadris.v4i2.3144

Permana, F. H., & Chamisijatin, L. (2019). Project-based learning through edmodo: improving critical thinking and histology concepts. *Biosfer*, *12*(1), 58–69. https://doi.org/10.21009/biosferjpb.v12n1.58-69

Petchtone, P., & Sumalee, C. (2014). The Validation of Web-based Learning Environment Model to Enhance Cognitive Skills and Critical Thinking for Undergraduate Students. *Procedia - Social and Behavioral Sciences*, *116*, 669–673. https://doi.org/10.1016/j.sbspro.2014.01.277

Putri, S. U., & Hendawati, Y. (2018). Blended Project Based Learning : Strategy for Improving Critical Thinking of Pre-Service Teachers in Science Education. *Proceeding of the 1st UR International Conference on Educational Sciences*, 978–979.

Rahayu, U., & Sapriati, A. (2018). Open educational resources based online tutorial model for developing critical thinking of higher Distance Education Students. *Turkish Online Journal of Distance Education*, *19*(4), 163–175. https://doi.org/10.17718/tojde.471914

Rakhmawati, I., Hasnunidah, N., & Priadi, M. A. (2020). Habits of Mind and Concept Mastery of Cell in Multimedia Virtual Class Environment: A Case of Biology Students in Lampung University. *E-Journal Ups*, *4*(januari 2020), 1–11.

Siti Rahmah dan Muhammad Kusas. (2016). Meningkatkan Keterampilan Berpikir Kritis Dan Hasil Belajar Siswa Menggunakan Strategi Pembelajaran Predict-Observe-Explain (Poe) Pada Materi Larutan Elektrolit-Nonelektrolit Dan Reaksi Reduksi Oksidasi. *Jurnal Inovasi Pendidikan Sains*, *7*(1), 39–45.

Suparini, S., Rusdi, R., & Ristanto, R. H. (2020). Guided discovery-blended learning (GDBL) for critical thinking skill empowerment: A learning strategy in human excretory system. *Biosfer*, *13*(2), 266–279. https://doi.org/10.21009/biosferjpb.v13n2.266-279

Susetyarini, E., & Fauzi, A. (2020). Trend of critical thinking skill researches in biology education journals across Indonesia: From research design to data analysis. *International Journal of Instruction*, *13*(1), 535–550. https://doi.org/10.29333/iji.2020.13135a

Suyanto, Y. P., Susanto, H., & Linuwih, S. (2012). Keefektifan Penggunaan Strategi Predict , Observe And Explain Untuk Meningkatkan Kemampuan Berpikir Kritis Dan Kreatif Siswa. *Journal of Physics Education*, *1*(2257).

Tiruneh, D. T., Verburgh, A., & Elen, J. (2014). Effectiveness of Critical Thinking Instruction in Higher Education: A Systematic Review of Intervention Studies. *Higher Education Studies*, *4*(1). https://doi.org/10.5539/hes.v4n1p1

Ventayen, R. J. M., Estira, K. L. A., Guzman, M. J. De, Cabaluna, C. M., & Espinosa, N. N. (2018). Usability Evaluation of Google Classroom: Basis for the Adaptation of GSuite E-Learning Platform Software Management View project Data Analysis View project. *Asia Pacific Journal of Education, Arts and Sciences*, *5*(1), 47–51.

Wahyuni, S., Gusti Made Sanjaya, I., Erman, & Jatmiko, B. (2019). Edmodo-based blended learning model as an alternative of science learning to motivate and improve junior high school students' scientific critical thinking skills. *International Journal of Emerging Technologies in Learning*, *14*(7), 98–110. https://doi.org/10.3991/ijet.v14i07.9980

Zenker, F. (2016). Introduction : Reasoning , Argumentation , and Critical Thinking Instruction. *Journal of Topoi*, 3–4. https://doi.org/10.1007/s11245-016-9416-x

Zhang, C., Fan, H., Xia, J., Guo, H., Jiang, X., & Yan, Y. (2017). The Effects of Re fl ective Training on the Disposition of Critical Thinking for Nursing Students in China : A Controlled Trial. *Journal of Asian Nursing Research*, 1–7. https://doi.org/10.1016/j.anr.2017.07.002

ŽivkoviÜ, S. (2016). A Model of Critical Thinking as an Important Attribute for Success in the 21st Century. *Procedia - Social and Behavioral Sciences*, *232*(April), 102–108. https://doi.org/10.1016/j.sbspro.2016.10.034