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PROBLEMS AND CHALLENGES IN 21ST CENTURY BIOLOGY LEARNING: A QUALITATIVE STUDY

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Abstract

Biology learning involves real-world problems including biodiversity, plants, and animals, as well as those important to students' daily lives. Biology learning in the 21st century is meant to give students active, relevant, and contextual learning, and it is directly tied to digitalization. This study aims to investigate the problems and challenges in teaching biology in public high schools in Kerinci Regency, Indonesia, in light of the needs of the 21st century. This is a survey study using qualitative data. A questionnaire was used as an instrument. Simple random sampling is used in the sampling procedure. The study included 166 students and 14 high school biology teachers who participated in this study from across Kerinci Regency. The Miles and Huberman approach is used in the data analysis technique, aided by the Atlas. ti 22 program. According to the findings, high school biology students and teachers in Kerinci Regency face several problems related to the biology study, including 1) latin language (biological terms); 2) laboratory (practicum); 3) material references (package books); and 4) learning that is considered uninteresting. The main challenges by biology teachers in the 21st century is adopting student-centered, active, meaningful, collaborative, and interesting learning. Technology is always evolving in the 21st century, biology teachers need to become more technologically and digitally literate.

Keywords: Biology Learning; Student Center; Active Learning; Meaningful Learning; Biology Terms

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INTRODUCTION

Biology learning material is relevant to everyday life (Mandasari, Iwan, & Damopolii, 2021), such as biodiversity, ecosystems, and the environment. Indoneisa has a large diversity of living creatures, including animals, plants, bacteria, fungi, protists, and others. Students studying biology can use the high amount of biodiversity as a contextual learning resource. Students are expected to be able to relate their daily experiences with scientific principles acquired in biology lessons (Sayuti, Sommer, & Ahmed-Kristensen, 2020). Furthermore, biological learning demands the development of reasoning abilities in addition to material understanding. Learning in biology classes may be understood as thinking activities to learn with comprehension rather than simply memorizing material (Amrianto, Rohman, Dharmawan, & Sari, 2024).

This emphasizes the significance of including active learning in biology learning. However, Santosa et al. (2021) discovered problems in one of Kerinci Regency's high

schools, specifically Senior High Schools 12 Kerinci Indonesia, such as students who were less involved in the teaching and learning process. The conventional learning paradigm which still considers the teacher as a center of learning (teacher centered learning) or as the only source of learning should be changed because it is not in accordance with the principles of teaching and learning (learning) itself (Jayawardana, 2017).

There are good reasons why group learning processes should be used to promote active learning. In group learning, students are involved in collaborative activities to produce knowledge through social interaction in groups (Amrianto, Lufri, & Anhar, 2020). Students get a better understanding of group work and social responsibility by teaching one another. Students develop knowledge when they share their insights and views during discussion activities. Interaction in the discussion process assists students in developing ideas, evaluating thinking, and developing reasoning abilities (Sueb, Muhdhar, & Zahroh, 2021). Meaningful learning occurs when a new notion taught is merged with previously studied relevant ideas and concepts.

The demands of learning biology are sometimes difficult for teachers to fulfill in class. Many problems are experienced by teachers and students. The problems of students in learning biology in each case are different. In previous research at the Kademangan State Vocational School (SMKN) Blitar Indonesia, there were several problems faced by students in learning, namely 1) the lack of student interest in biology learning material because it was considered too rote and boring; 2) there are no textbooks that are in accordance with the competencies needed by SMK students so far learning still relies on worksheets and modules developed by teachers; 3) the utilization of local potential that exists around schools is not yet optimal to make it easier for students to understand concepts in learning biology (Kusuma, Rohman, & Syamsuri, 2017). These issues may also arise in different regions and classes.

Research conducted at Senior High Schools 44 Jakarta Indonesia found that the problems faced by students were 1) the tendency of students to be lazy in studying biology material; 2) decreased student honesty because of the courage to learn; 3) students' activeness in learning biology in class decreases (Aryani, Hanafiah, Zahra, Janah, & Suryanda, 2022). Student problems in learning biology is a complex problem. The challenges of teachers as educators are getting tougher along with the changing times. Based on research at the high school level in Lombok, students also have problems in learning biology, including 1) use of scientific names: 2) topic complexity; and 3) student study habits (Hadiprayitno, Muhlis, & Kusmiyati, 2019). The study also explained that the topics that were difficult for students to learn were bacteria and viruses (18.64%).

It is also known from research conducted at Madrasah Aliyah 2 Padang Indonesia that students' biology problems are 1) students have difficulty understanding biology material; 2) lack of focus and concentration of student learning; 3) there is a discrepancy in the understanding of the concept and the type of evaluation test used by the teacher (Azizah & Alberida, 2021). The problems obtained in the field can be used as material for reflection so that in the future it can be even better.

Digitalization is another feature of the 21st century. Technology is rapidly evolving and continuing to benefit many disciplines, including education (Amrianto, 2021). The increasingly complicated needs of 21st century advances affect their implementation in schools. As a result, it is critical to look into the problems and obstacles in learning biology in high schools about the previously outlined biology learning needs. The purpose of this study is to provide answers to the following questions:

1. What are the problems and challenges that High School students face when learning biology in the 21st century?
2. What are the problems and challenges that High School teachers face when learning biology in the 21st century?

METHODS

This research is qualitative research with a survey method. The research was carried out from January to April 2022. Simple random sampling is used as a sampling technique. The study included 166 students and 14 high school biology teachers who participated in this study from across Kerinci Regency. Table 1 shows the distribution of responders.

Table 1.
Research Sample Distribution

School Code	Numbers of Student	Numbers of Teacher
S1	7	1
S2	4	1
S3	14	1
S4	23	1
S5	12	1
S6	20	1
S7	29	1
S8	8	1
S9	10	1
S10	15	1
S11	6	1
S12	4	1
S13	9	1
S14	5	1
Total	166	14

Source: Researcher

A questionnaire was employed as the research instrument in this research. The questionnaire contains open-ended questions aimed at teachers and students. Table 2 shows the questionnaire items for teachers and students.

Table 2.
Questionnaire Items

No	Variable	Item	Information
1	Problems that students face when learning biology.	What problems do you frequently experience when learning biology as a student?	Open-ended questions without limiting the answers
2	Problems that teachers face when learning biology.	What problems do you frequently experience when learning biology as a teacher?	

Source: Researcher

The data analysis technique uses the Miles and Huberman technique assisted by the Atlas.ti 22 application. Miles and Huberman's analysis technique consists of three stages, namely data reduction, data presentation, and conclusion (Miles & Huberman, 1994). The Atlas.ti 22 application is used to assist qualitative data analysis based on sentence similarity. The complete research procedure can be seen in Figure 1.

RESULTS & DISCUSSION

Results

The research findings included 12 problems that students encountered while learning biology. Researchers only identify four problems that students frequently complain about when studying biology, including 1) difficulty in reading, understanding and memorizing biological terms; 2) passive learning; 3) uninteresting learning; 4) meaningless learning. Table 3 lists all of the challenges that are encountered by students when learning biology depicts the display of research data.

Table 3.
Student Problems in Biology Learning at High School in Kerinci Regency

No	Problems in Biology Learning	Frequency of Words Appearing
1	Difficulty Reading, Understanding, and Memorizing Latin Language	47
2	Meaningless Learning	17
3	Uninteresting Learning	15
4	Passive Learning	14
5	The Deduction of Study Time During Covid-19*	8
6	Teacher Responsibilities (Rarely Study)	7
7	Lack of Laboratory Equipment	5
8	Doesn't Have a Laboratory	5
9	Lack of Material References	4
10	Teacher Pedagogy (Using a Low Voice When Teaching)	4
11	Lack of Utilization of Digitalization Technology	3
12	Doesn't like social activities	2
13	Many tasks	1
14	Depth of Material (Teacher Professional Competency)	1
15	Difficulty Presenting Material in Front of the Class	1
16	Lack of Classroom Management Skills by Teachers	1
17	Teacher Pedagogy (Not Firm)	1
18	Unsystematic Learning Implementation	1
19	It's Difficult to Practice in the Field Due to Covid-19*	1
20	Uncomfortable with Group Division	1
21	Inability to Express Opinions	1
	Total	140

** It is not an issue because the Covid 19 era has ended.*

Source: Researcher

Table 3 shows that biology learning in the classroom still faces numerous challenges and does not satisfy the expectations of 21st century learning needs. Aside from that, the results of the teacher identification of challenges in biology learning included eight problems. Researchers only looked at the two problems that teachers raised the most regarding biology learning: laboratories and a lack of reading materials (literature). Table 4 lists all of the difficulties encountered by teachers when learning biology depicts the display of research findings.

Table 4.
Teacher Problems in Biology Learning at High School in Kerinci Regency

No	Challenges in Biology Learning	Frequency of Words Appearing
1	Laboratories	6
2	Lack of Reading Material (Literature)	4
3	Latin language	1
4	Reduced Student Interest in Learning	1
5	Environmental Factors (Weather)	1
6	Internet Network	1
7	Lack of Student Interest in Reading Source Books/Literature	1
8	Practicum is impeded since learning hours are not yet back to normal (COVID 19 effect)*	1
	Total	16

* It is not an issue because the Covid 19 era has ended.
Source: Researcher

Table 4 shows that teachers have problems with media (reading materials) and laboratories (practicum). By drawing an intersection diagram of the two data, the two data sources, namely teachers and students, may create a common thread. Figure 2 depicts an intersection diagram of the two data.

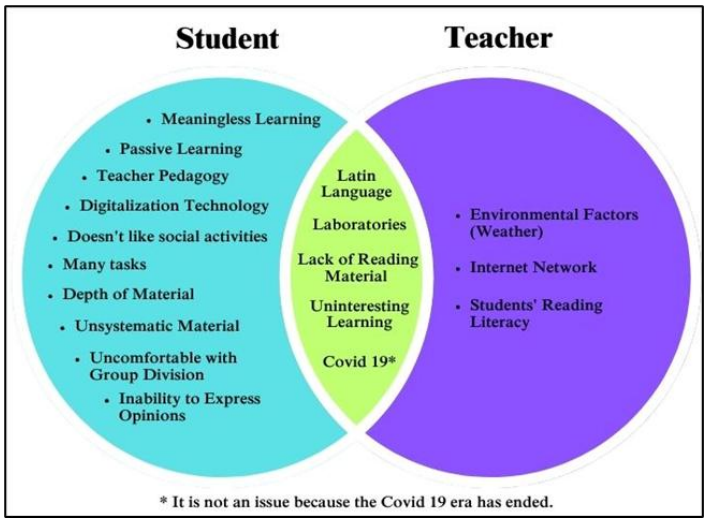

Figure 1.
Venn Diagram of Data nn Problems Faced by Students And Teachers in 21st Century Biology Learning
Source: Researcher

Figure 1 shows the similarity in the solutions provided by students and teachers. Intersectional problems include Latin language problems, laboratories (practicums), reference materials (package books), and uninteresting learning.

Discussion

1. Problems and Challenges Experienced by Students in Biology Learning

   According to Table 3, there are numerous problems with studying biology. There are four problems that students have when studying biology at Kerinci Regency high schools: 1) passive learning; 2) learning that is not interesting; 3) meaningless learning; and 4) difficulty reading, understanding, and memorizing biological terms.

   First, the learning is done passively. Students frequently complain about being required to take notes on the subject matter, as in the student's answer, namely:
   Student Code S1-22:
   "*Often given the task of taking notes*"

   Student Code S3-10:
   "*I don't focus enough when studying biology, because the teacher only explains the material*"

   Student Code S6-14:
   "*It's boring if the explanation of the material is continued*"

   Biology study that consists solely of note-taking activities and explanations may cause students to become passive and only focus on content learning. The teacher's paradigm in managing a learning process, especially learning biology, must begin to change. Learning biology is not just lectures and notes. Teaching science, in this instance biology, is not just to provide students with concepts and principles, but also to help them comprehend why knowledge is vital in their lives and the lives of others (Krahenbuhl, 2016). Biology is not textual in nature which is learned only through text or books, because there are certain materials that are difficult to understand if you only rely on text (Jayawardana, 2017). This is consistent with the educational perspective, which emphasizes implementing student-centered learning.

   Active learning may be used to implement learning that is delivered to pique students' attention and activity (Amrianto et al., 2020). The primary goal of active learning is to educate students to share information about the learning problems they are experiencing (Yang, Vong, Yu, & Shafto, 2019), focus on creativity, critical awareness, self-initiative, and ways how students can be more actively involved in the learning process (Nur, 2016). Matsushita (2017) defines various characteristics of active learning, namely 1) students are spending more time listening; 2) less emphasis is being placed on transmitting information and more on developing student skills; 3) students are engaging in higher-order thinking (analysis, synthesis, and evaluation); 4) students are participating in activities (such as reading, discussing, and writing); and 5) there is a greater emphasis on students' exploration of their attitudes and values.

   Additionally, constructivist education and active learning are intricately intertwined. Constructivist teaching is an effective teaching strategy because it fosters student responsibility and autonomy while encouraging active and meaningful learning. Constructivism's primary tenet is student autonomy. Encouraging students to ask questions about the material being covered can help them become more independent learners (Panhwar, Ansari, & Ansari, 2016).

Constructivism-based learning assists students in developing their knowledge based on previous information (Fitriani, Zubaidah, Susilo, & Al Muhdhar, 2020a). Well-constructed information will stay with students for a long time and make learning more meaningful. Constructive learning implies that students construct learning, knowledge, and reality via interactions with other people, which impact how learning is received, applied, and developed (Schaefer, Fabian, & Kopp, 2020). Furthermore, Ahmad et al, (2020) promotes constructivism learning through Problem Based Learning (PBL). PBL (Problem Based Learning) assists students in mastering learning situations. When students participate in an activity, they get an understanding of the significance of the problem, become aware of the ramifications of the topic, and arrange their knowledge based on their own experience. Providing problems in biology learning is also very important, particularly problems that arise around students. Students might be motivated to learn through problems (Asyari, Muhdhar, Susilo, & Ibrohim, 2016). Second, meaningless learning. Students' mindsets are still constrained in that studying biology is limited to memorizing, and practicum is rarely used as a way of applying learning principles, as in the student's answer, namely:

Student Code S4-37:
"It's hard to understand about bacteria and hard to memorize"

Student Code S5-01:
"The obstacle I faced in studying biology was that the teacher asked me to memorize the material in the notebook"

Student Code S10-24:
“Hard to memorize things”

Biology teachers should work hard to make biology subjects more relatable to students. Meaningful learning occurs when a new notion taught is merged with previously studied relevant ideas and concepts. Students must incorporate new ideas or concepts into their current cognitive structures. Furthermore, significant learning may be accomplished through discussion activities. Facilitating discussions helps students to share their thoughts with their peers and receive feedback from them (Fitriani, Zubaidah, Susilo, & Al Muhdhar, 2020b). Peer learning may also be used to facilitate meaningful learning. Interaction with others allows individuals to form connections, enhance motivation, accept peer instruction, and effectively work with others (Borup, Walters, & Call-cummings, 2020). Guidance at the same age, on the other hand, is advised to be conducted in the classroom since it is more beneficial (Alegre, Moliner, Maroto, & Lorenzo-valentin, 2019).

Students would rather talk with their friends than with their teachers. The first and most prevalent reason students choose to discuss with their friends before their teacher is because they feel their teacher is too busy to help, especially when it is outside of their working hours. They are more at ease speaking with their peers than with their teachers (Borup et al., 2020). Students report that they like discussing with their classmates and feel that the discussions help them gain a better grasp of science (Cole et al., 2018). Third, learning is not interesting. Students become bored as a result of uninteresting learning. In general, student responses indicated that they were bored, sleepy, had difficulties concentrating, and so on, as in the student's answer, namely:

Student Code S3-15:
“Often feel bored and unenthusiastic”

Student Code S6-02:
"Often feel bored when studying, lessons are sometimes not interesting"

Student Code S3-03:
"Sleepy"

This is frequently impacted by learning practices that are still centered on the teacher and unappealing learning media. One strategy for making learning more engaging is for the teacher to use a variety of teaching methods, one of which is cooperative learning. Cooperative learning entails teams working together to facilitate all members' learning (Buchs, Filippou, Pulfrey, & Volpé, 2017). Group activities, such as discussions, will keep students engaged by providing relevant group activities. Group activities can provide opportunities for students to explore broader knowledge, because more ideas are put forward (Lufri, Amrianto, & Anhar, 2019).

Rodríguez et al. (2019) also discussed the importance of cooperation among colleagues from various backgrounds in the process of knowledge development. Cooperation is an important aspect of cooperative model learning (Miquel & Duran, 2017). The social nature of cooperative learning, as well as the emphasis on group work and collaboration, can provide students with social, behavioral, and academic benefits (Ryzin & Roseth, 2019). Furthermore, the learning medium can be modified to pique students' attention. A new environment will entice students to pay attention to and comprehend what they are studying (Lufri, Fitri, & Yogica, 2018).

Cooperative learning can provide several benefits, including an improvement in students' communication skills and emotional intelligence (Moradi, Faghiharam, & Ghasempour, 2018). Group learning may be implemented in a variety of ways, including elaborating on age, gender, and so on. The mixed-sex group, on the other hand, had the highest level of cooperation (Peshkovskaya, Babkina, & Myagkov, 2019).

The existence of a clear division of tasks becomes a priority during group learning so that students do not feel bored. If no defined position is specified, everyone in the group will do everything, which might lead to uncertainty among group members about what their role is. It also prompts students who are unmotivated to wait for someone else to tell them what to do. If they are allocated a specific role, it inspires them to concentrate on their studies and the activities at hand (Stanley, 2016). It is during this period of sharing roles that chances for individual and especially group innovation develops, motivating each team to perform more and achieve higher outcomes (Tang, Vezzani, & Eriksson, 2020). Fourth, it is clear from Table 3 that students continue to struggle with reading, interpreting, and recalling biological terms, as in the student's answer, namely:

Student Code S4-06:
“I had a hard time understanding Latin in biology class”

Student Code S5-09:
"It is difficult to memorize the material given, because biology has many scientific names that are difficult to memorize"

Student Code S8-07:
"Sometimes I get confused by the Latin pronunciation in biology. During the oral exam, I had difficulty pronouncing it, sometimes I wrote cheat sheets on my hand to make it easier to remember."

Student Code S11-08 Answers:
"There are lots of terms in biology class that use Latin which are hard to pronounce. So during the presentation, I had difficulty pronouncing the Latin name, like the bacteria used in making yogurt"

Biology terms are important for students to understand, because it is an important part of understanding biological material (Kameswari, 2022). Students complain about the term biology since it is difficult to read and comprehend. These problems arise mostly because students are not accustomed to reading and hearing these terminologies, making them difficult to comprehend. According to Hernawati et al. (2018), repeated emphasis can increase students' comprehension of the material.

Another alternative that can be done to hone the memorization of biological terms is 1) BIOLARGA (BIOlogi uLAR tangGA), is a learning media that is used to make it easier for students to memorize scientific names, this learning media is a modification of the "Ular Tangga" game and there are cards containing question. Students must answer the question correctly. BIOLARGA learning media is applied by learning while playing (Sofiyan, Maris, Affiyah, & Khumaiya, 2020) and; 2) the Mnemonic method, Mnemonics can improve students' memory (Kurmalasari, Habibah, Elvi, & Zaitun, 2021; Siregar, 2020).

2. Problems and Challenges experienced by Teachers in Biology Learning

First, the laboratory. Teachers continue to complain about a lack of facilities and infrastructure in practicum laboratories, such as instruments and supplies for practicums. This is evident from the teacher's response, namely:

Teacher code S6-GM:
"Limitations on teaching aids and chemicals in the laboratory"

Teacher code S12-IM:
"There is still limited ownership of science laboratory equipment"

Students can build concepts about the nature of science and scientific communities via experience in laboratory performance. The laboratory is seen as an embodiment of science and the place for the formation of scientific knowledge and understanding. Aside from that, several laboratories are now experimenting with virtual worlds, such as AR (Augmented Reality) (Akçayır, Akçayır, Pektas, & Ocak, 2016) and VR (Virtual Reality) (Alalwan et al., 2020; Lamb, Lin, & Firestone, 2020). Virtual laboratories can dynamic visualization for student comprehension (Herga, 2016). However, the sophistication of AR and VR poses problems for classroom use, such as instructor competency, restricted learning design, lack of focused attention, time constraints, and limited environmental resources (Alalwan et al., 2020). Figure 3 shows further facts about challenges encountered while implementing AR and VR.

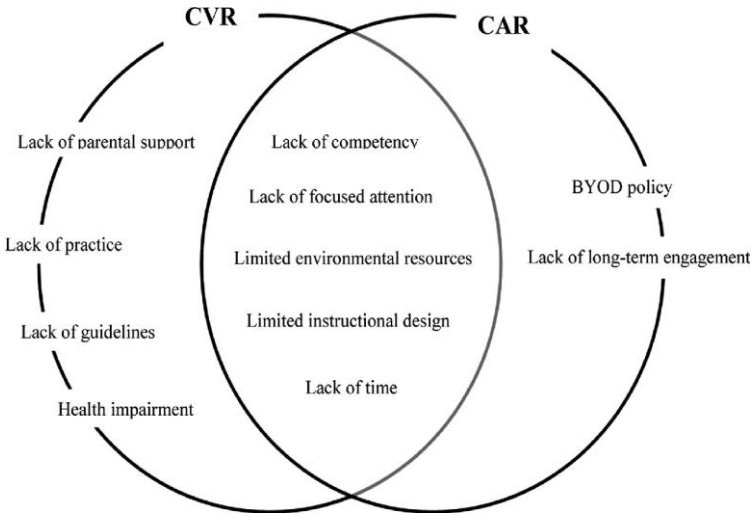

Figure 2.
Challenges of applying AR and VR in the classroom (Alalwan et al., 2020)
Source: Researcher

A survey done by Rahman et al., (2022) identified research related to VR in schools from 2016 to 2021, and the findings revealed that biology courses used VR in learning the least compared to physics and chemistry disciplines. Given that science is increasingly growing with technology, it is a significant challenge for biology teachers to continue to innovate in education and technology. However, it should be noted that practicums are not limited to laboratories and advanced equipment. There are several additional options for making learning more engaging and contextual. Simple practicums can be completed in a school environment. The perspective that has to be altered about biology practicum is that practice does not have to be done simply in a laboratory room, nature is a limitless laboratory that may be explored as extensively as possible.

A teacher must be aware of current advancements, namely the use of technology in the classroom because numerous innovations have evolved in the 21st century to enhance learning in the classroom. Teachers must have good digital literacy abilities and comprehension to teach in the classroom. Advanced information and communication technology is increasingly at the forefront, and teachers must adjust their teaching approaches to meet the challenges of the 21st century (Herga, 2016). Second, lack of reading material (literature). Teachers worry about a shortage of reading resources for students, namely textbooks, as stated in the teacher's response:

Teacher Code S3-S:
“Not enough reading books available”

Teacher Code S10-AN:
“Lack of Media (texts books)”

Textbooks or similar reading materials are useful resources for biology learning. Lack of reading material is no longer a significant barrier to learning in the 21st century, as knowledge is readily disseminated over the internet. Reading materials are no longer restricted to physical books; there are now electronic books (e-book) that are widely distributed and may be accessed for free (Bergström & Höglund, 2020).

It is crucial to highlight, however, that much digital information might have a detrimental influence on students. Students must be taught how to filter through material on the internet because much of it is unclear and can be misleading to students. Students are frequently perplexed by the amount of information they get. Students must be taught to critically evaluate internet information sources. Critical thinking abilities may be used to analyze arguments and incorrect assumptions connected to information collected by students (OECD, 2018). However, teaching students to be critical of the sources and information they get is a difficult task (Landøy, Popa, & Repanovici, 2020). This is an important challenge for teachers in the 21st century.

To make it easier for readers to understand the problems and challenges of the 21st century in this research, Figure 4 presents a modeling diagram of the problems and challenges in teaching biology in the 21st century in this research.

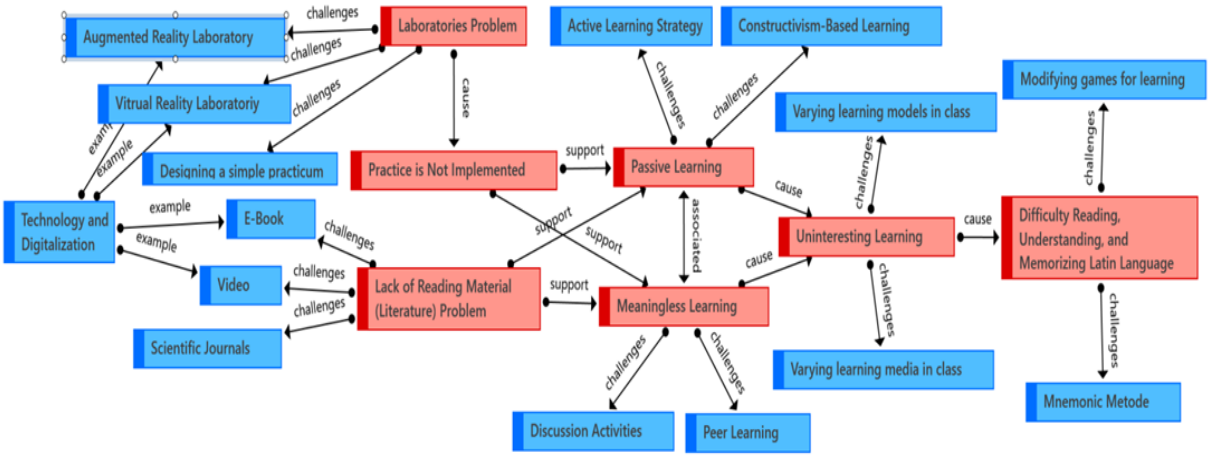

Figure 3.
Modeling Diagram of Problem and Challenges in 21st Biologi Learning
Source: Researcher

Figure 3 explains that problems and challenges in learning are complex topics. There is correlation, cause and effect, and support from various aspects. Each aspect will influence other aspects. It is important to consider many things, so as not to regret later. Problems can be used as material for reflection to continue to be improved and perfected.

CONCLUSION

According to the findings of the study, high school students in Kerinci Regency continue to struggle with learning biology, including (1) difficulty reading, understanding, and memorizing biological terms 2) passive learning; 3) learning that is considered uninteresting; 4) Learning is viewed as meaningless. Other than that, teachers have challenges with laboratory infrastructure and student reading materials. There is a

gap between the challenges that students and teachers encounter in biology learning, such as Latin, laboratories (practicums), reference material (package books), and learning that is considered uninteresting. Implementing student-centered learning, active, meaningful, collaborative, and enjoyable learning are major difficulties facing biology teachers. Apart from that, teachers must develop their technical and digital literacy to produce innovations in classroom learning.

The researcher's difficulty in ensuring that students completed all questionnaire items presented was a limitation of this study. The larger the study population, the more difficult it would be to supervise, requiring a proportional number of supervisors to monitor students completing the questionnaires. This can be improved in the future, and it is intended that future studies would use effective and diverse measuring methods for data collecting, resulting in a diverse and vast set of data. Furthermore, this study was limited to high school students in Kerinci Regency. Perhaps in the future, a similar study can broaden the population range that will be utilized.

REFERENCES

Ahmad, S., Sultana, N., & Jamil, S. (2020). Behaviorism vs Constructivism: A Paradigm Shift from Traditional to Alternative Assessment Techniques Sadia Jamil. *Journal of Applied Linguistics and Language Research*, *7*(2), 19–33. Retrieved from www.jallr.com

Akçayır, M., Akçayır, G., Pektas, H. M., & Ocak, M. A. (2016). Augmented reality in science laboratories: The effects of augmented reality on university students' laboratory skills and attitudes toward science laboratories. *Computers in Human Behavior*, *57*, 334–342. https://doi.org/10.1016/j.chb.2015.12.054

Alalwan, N., Cheng, L., Al-samarraie, H., Yousef, R., Ibrahim, A., & Muthana, S. (2020). Studies in Educational Evaluation Challenges and Prospects of Virtual Reality and Augmented Reality Utilization among Primary School Teachers: A Developing Country Perspective. *Studies in Educational Evaluation*, *66*(March), 100876. https://doi.org/10.1016/j.stueduc.2020.100876

Alegre, F., Moliner, L., Maroto, A., & Lorenzo-valentin, G. (2019). Peer tutoring and mathematics in secondary education : literature review, effect sizes, moderators, and implications for practice. *Heliyon*, *5*(September), e02491. https://doi.org/10.1016/j.heliyon.2019.e02491

Amrianto. (2021). *Remaja vs Pendidikan*. Bogor: Guepedia.

Amrianto, Lufri, & Anhar, A. (2020). *Active Learning and Evaluation of Education in Indonesia*. Mauritius: Lambert Academic Publishing.

Amrianto, Rohman, F., Dharmawan, A., & Sari, M. S. (2024). Development of a 4C skills evaluation instrument for biology: A validity and reliability study on Indonesian high school students learning. *International Journal of Innovative Research and Scientific Studies*, *7*(2), 701–717. https://doi.org/10.53894/ijirss.v7i2.2873

Aryani, L. D., Hanafiah, A. H., Zahra, S. N., Janah, T. R., & Suryanda, A. (2022). Studi Analisis Permasalahan Pembelajaran Biologi di Sekolah Urban. *Jurnal Penelitian, Pendidikan Dan Pengajaran*, *3*(2), 104–108.

Asyari, M., Muhdhar, M. H. I. Al, Susilo, H., & Ibrohim. (2016). Improving critical thinking skills through the integration of problem based learning and group investigation. *International Journal for Lesson and Learning Studies*, *5*(1), 36–44. Retrieved from https://doi.org/10.1108/IJLLS-10-2014-0042

Azizah, N., & Alberida, H. (2021). Seperti Apa Permasalahan Pembelajaran Biologi pada Siswa SMA? *Journal for Lesson and Learning Studies*, *4*(3), 388–395.

Bergström, A., & Höglund, L. (2020). E-books: In the shadow of print. *Convergence: The International Journal of Research into New Media Technologies*, *26*(4), 895–911. https://doi.org/10.1177/1354856518808936

Borup, J., Walters, S., & Call-cummings, M. (2020). Student Perceptions of Their Interactions with Peers at a Cyber Charter High School. *Online Learning*, *24*(2), 207–224. Retrieved from https://doi.org/10.24059/olj.v24i2.2015

Buchs, C., Filippou, D., Pulfrey, C., & Volpé, Y. (2017). Challenges for cooperative learning implementation: reports from elementary school teachers. *Journal of Education for Teaching*, *43*(3), 296–306. https://doi.org/10.1080/02607476.2017.1321673

Cole, R., Buchenroth-Martin, C., Weston, T., Devine, L., Myatt, J., Helding, B., … Ward, W. (2018). One-on-one and small group conversations with an intelligent virtual science tutor. *Computer Speech and Language*, *50*, 157–174. https://doi.org/10.1016/j.csl.2018.01.002

Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020a). PBLPOE: A learning model to enhance students' critical thinking skills and scientific attitudes. *International Journal of Instruction*, *13*(2), 89–106. https://doi.org/10.29333/iji.2020.1327a

Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020b). The effects of integrated problem-based learning, predict, observe, explain on problem-solving skills and self-efficacy. *Eurasian Journal of Educational Research*, *2020*(85), 45–64. https://doi.org/10.14689/ejer.2020.85.3

Hadiprayitno, G., Muhlis, & Kusmiyati. (2019). Problems in learning biology for senior high schools in Lombok Island Problems in learning biology for senior high schools in Lombok Island. In *The International Seminar on Bioscience and Biological Education*. https://doi.org/10.1088/1742-6596/1241/1/012054

Herga, N. R. (2016). Virtual Laboratory in the Role of Dynamic Visualisation for Better Understanding of Chemistry in Primary School. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(3), 593–608. https://doi.org/10.12973/eurasia.2016.1224a

Hernawati, D., Amin, M., Irawati, M., Indriwati, S., & Aziz, M. (2018). Integration of project activity to enhance the scientific process skill and self-efficacy in Zoology of Vertebrate teaching and learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(6), 2475–2485. https://doi.org/10.29333/ejmste/89940

Jayawardana, H. B. . (2017). Paradigma pembelajaran biologi di era digital. *Jurnal Bioedukatika*, *V*(1).

Kameswari, D. (2022). Pengetahuan Mahasiswa Biologi terhadap Penggunaan Terminologi Bahasa Latin. *Research and Development Journal Of Education*, *8*(1), 256–262.

Krahenbuhl, K. S. (2016). Student-centered Education and Constructivism : Challenges , Concerns , and Clarity for Teachers Clarity for Teachers. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *8655*(July). https://doi.org/10.1080/00098655.2016.1191311

Kurmalasari, T., Habibah, S., Elvi, M., & Zaitun. (2021). Sosialisasi Mengingat Cepat dengan Teknik Mnemonik dalam Mengembangkan Karakter dan Kreativitas Siswa di PKBM Harapan Bangsa. *Abdimas Pedagogi: Jurnal Ilmiah Pengabdian Kepada Masyarakat*, *4*(2), 57–61.

Kusuma, R. D., Rohman, F., & Syamsuri, I. (2017). The Biology Learning Problem on

Agriculture Department of Public Vocational School 1 Kademangan, Blitar. In *Prosiding Seminar Nasional III tahun 2017 "Biologi, Pembelajaran, dan Lingkungan Hidup Perspektif Interdisipliner" Diselenggarakan oleh Prodi Pendidikan Biologi-FKIP bekerjasama dengan Pusat Studi Lingkungan dan Kependudukan (PSLK) Universitas Muhammadiya* (pp. 133–136).

Lamb, R., Lin, J., & Firestone, J. B. (2020). Virtual Reality Laboratories : A Way Forward for Schools ? *EURASIA Journal of Mathematics, Science and Technology Education*, *16*(6).

Landøy, A., Popa, D., & Repanovici, A. (2020). *Collaboration in Designing a Pedagogical Approach in Information Literacy*. Switzerland: Springer.

Lufri, Amrianto, & Anhar, A. (2019). Pengaruh Metode Example Non Example terhadap Kompetensi IPA Peserta Didik pada Materi Interaksi Makhluk Hidup. *Ta'dib*, *22*(2), 99–104.

Lufri, L., Fitri, R., & Yogica, R. (2018). Development of Learning Models Based on Problem Solving and Meaningful Learning Standards by Expert Validity for Animal Development Course. *IOP Conference Series: Materials Science and Engineering*, *335*(1). https://doi.org/10.1088/1757-899X/335/1/012094

Mandasari, F., Iwan, I., & Damopolii, I. (2021). The relationship between science process skills and biology learning outcome. *Journal of Research in Instructional*, *1*(1), 23–32. https://doi.org/10.30862/jri.v1i1.9

Matsushita, K. (2017). *Deep Active Learning: Toward Greater Depth in University*. Japan: Springer.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis*. *Sage*. California: Sage Publications.

Miquel, E., & Duran, D. (2017). Peer Learning Network: implementing and sustaining cooperative learning by teacher collaboration. *Journal of Education for Teaching*, *43*(3), 349–360. https://doi.org/10.1080/02607476.2017.1319509

Moradi, S., Faghiharam, B., & Ghasempour, K. (2018). Relationship Between Group Learning and Interpersonal Skills with Emphasis on the Role of Mediating Emotional Intelligence Among High School Students. *Sage Open*, 1–10. Retrieved from https://doi.org/10.1177/2158244018782734

Nur, D. R. (2016). Student Active –Learning: a Curriculum Innovation in Indonesia. *LINGUA: Journal of Language, Literature and Teaching*, *11*(1), 23. https://doi.org/10.30957/lingua.v11i1.17

OECD. (2018). *Social and Emotional Skills Well-being, connectedness and success*. Paris: OECD.

Panhwar, A. H., Ansari, S., & Ansari, K. (2016). Sociocultural Theory and its Role in the Development of Language Pedagogy. *Advances in Language and Literary Studies*, *7*(6). https://doi.org/10.7575/aiac.alls.v.7n.6p.183

Peshkovskaya, A., Babkina, T., & Myagkov, M. (2019). Gender effects and cooperation in collective action : A laboratory experiment. *Rationality and Society*. https://doi.org/10.1177/1043463119858788

Rahman, F., Mim, M. S., Baishakhi, F. B., Hasan, M., & Morol, M. K. (2022). A Systematic Review on Interactive Virtual Reality. In *Proceedings of the 2nd International Conference on Computing Advancements.*

Rodríguez, G., Pérez, N., Núñez, G., Baños, J. E., & Carrió, M. (2019). Developing creative and research skills through an open and interprofessional inquiry-based learning course. *BMC Medical Education*, *19*(1), 1–13. https://doi.org/10.1186/s12909-019-1563-5

Ryzin, M. J. Van, & Roseth, C. J. (2019). Cooperative learning e ff ects on peer relations

and alcohol use in middle school. *Journal of Applied Developmental Psychology*, *64*(January), 101059. https://doi.org/10.1016/j.appdev.2019.101059

Santosa, T. A., Zulyusri, Z., & Lufri, L. (2021). Analysis of Educational Problems and Biology Learning in Senior High School in Kerinci Regency. *Sainstek : Jurnal Sains Dan Teknologi*, *13*(1), 7. https://doi.org/10.31958/js.v13i1.2646

Sayuti, A. N. 'Ayn, Sommer, B., & Ahmed-Kristensen, S. (2020). Identifying the Purposes of Biological Materials in Everyday Designs. *Environment-Behaviour Proceedings Journal*, *5*(15), 29–37. https://doi.org/10.21834/ebpj.v5i15.2479

Schaefer, T., Fabian, C. M., & Kopp, T. (2020). The dynamics of online learning at the workplace: Peer-facilitated social learning and the application in practice. *British Journal of Educational Technology*, *51*(4), 1406–1419. https://doi.org/10.1111/bjet.12894

Siregar, S. (2020). Pembelajaran Sistem Ekskresi dengan Metode Mnemonik untuk Meningkatkan Retensi (Daya Ingat) dan Hasil Belajar Siswa. *Serambi Konstruktivis*, *2*(1), 77–83.

Sofiyan, A., Maris, A. F., Affiyah, Z., & Khumaiya, L. (2020). Media Pembelajaran Biolarga (Biologi Ular Tangga) untuk Menghafal Nama-Nama Ilmiah. *NECTAR: Jurnal Pendidikan Biologi*, *1*(2), 35–42.

Stanley, T. (2016). *Creating Life-Long Learners : Using Project- Based Management to Teach 21st Century Skills*. *Sage*. Thousand Oaks: Corwin.

Sueb, Muhdhar, M. H. I. Al, & Zahroh, V. R. A. (2021). The Effect of Inquiry-Based Ecosystem Learning Module from Fishponds as a Learning Resource on Students' Cognitive Ability. *Journal of Physics: Conference Series*, *1842*(1). https://doi.org/10.1088/1742-6596/1842/1/012041

Tang, T., Vezzani, V., & Eriksson, V. (2020). Developing critical thinking, collective creativity skills and problem solving through playful design jams. *Thinking Skills and Creativity*, 100696. https://doi.org/10.1016/j.tsc.2020.100696

Yang, S. C. H., Vong, W. K., Yu, Y., & Shafto, P. (2019). A Unifying Computational Framework for Teaching and Active Learning. *Topics in Cognitive Science*, *11*(2), 316–337. Retrieved from https://doi.org/10.1111/tops.12405.