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Profile of Students' Critical and Creative Thinking Skills on Virus Material: The Need for Learning Innovation

Oktaviariesta H. Sholikhah[1], Suranto[2*], Slamet Santosa[2]

[1] Master of Biology Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia
[2] Department of Biology Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia

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Corresponding Author:
Suranto
suranto57@staff.uns.ac.id

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Abstract: This research intends to describe a preliminary study of students' critical and creative thinking skill profiles at one of the State High Schools in Madiun, East Java, as well as their empowerment efforts. The type of research carried out was quantitative descriptive. The research population was students who had received virus material. This study's data collection used questionnaires and essay questions adjusted to the sub-indicators of critical and creative thinking skills. The findings indicated that 86.4% of pupils encountered difficulties comprehending virus-related content. The learning method that is often used is the conventional method, the learning resources that were often used were textbooks and PowerPoint as a frequently used learning medium. The correlation between the biology textbook used with critical thinking indicators is only 27.78% and 28.13% for creative thinking indicators. The profile of students' critical thinking skills obtained results of 32.23% (Interpretation), 28.97% (Analysis), 30.08% (Inference), 24.16% (Evaluation), 33.56% (Explanation), and 34.29% (Self-regulation). The profile of students' creative thinking skills obtained results of 37.07% (Fluency), 30.83% (Flexibility), 35.68% (Originality), and 27.96% (Elaboration). The conclusion is that students' critical and creative thinking skills are relatively low, so innovative learning is needed to empower these skills.

Keywords: Creative Thinking Skills; Critical Thinking Skills; Learning Innovation; Profile of High School Students

Introduction

The 21st century has seen an incredible development in science and technology that affects all aspects of human existence. Presently, the globe has entered the period of Industrial Revolution 4.0, distinguished by the implementation of automation overseen by artificial intelligence and digital physical frameworks (Shahroom & Hussin, 2018). Various sectors of life have experienced changes with the Industrial Revolution 4.0, one of which is the education sector (Baygin et al., 2016). The education sector is the main key to a country's development and progress and also needs to adapt to current developments so as not to be left behind by other countries. The 21st century requires students to master a number of skills, namely creativity, critical thinking and problem-solving, collaboration, and communication, which are useful as provisions for producing innovation (Lin et al., 2018).

The skills required in the 21st century are intimately linked to higher-order thinking skills (HOTS), which necessitate pupils to cultivate and adjust, so HOTS abilities are competencies that students must have (Urbani et al., 2017). However, a lot of learning still does not revolve around HOTS, including developing critical and creative thinking. One of the keys to student success is critical and creative thinking skills. Therefore, the government, through the education system, is trying to produce a generation that is able to ask questions, think creatively, solve problems, participate, have knowledge, and communicate effectively (Vong & Kaewurai, 2017). Critical and creative thinking abilities are crucial for making students able to analyze all complex things thoroughly to create the right conclusions. Critical and

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creative thinking have a relationship that allows individuals to produce arguments in solving problems.

Critical thinking is a skill that has high-level thinking power that allows students to study reality, evaluate more aspects, find solutions to problems, and verify and check their own opinions (Gojkov et al., 2015). Learning activities focusing on critical thinking abilities stimulate students' understanding and enable them to develop into perceptive and adaptable persons (Chukusol & Piriyasurawong, 2022). The six indications of critical thinking skills are interpretation, analysis, evaluation, inference, explanation, and self-regulation (Facione, 2015). Guilford (1995) stated that creative thinking skills are a unique mental process that is capable of creating something different, new, and original based on specific thoughts (Sucilestari et al., 2023). Someone who can think creatively makes it easier to develop a framework because that person tends to have broad knowledge and inspiration (Yang et al., 2016). Creative thinking includes fluency, flexibility, originality, and elaboration (Torrance, 1968).

Individuals' ability to solve problems and understand the surrounding environment can be improved through critical and creative thinking skills in the education system (Suradika et al., 2023). However, in fact, based on Program for International Student Assessment (PISA) data, Indonesia 2015 ranked 62nd (score 395) out of 70 countries (OECD, 2016), in 2018, it ranked 71st (score 382) out of 78 countries (OECD, 2019), and in 2022 it will be 69th out of 81 countries (OECD, 2023). The low results of the PISA survey, which are viewed from the average Mathematics, Science, and Reading scores, show that students' critical thinking skills are still lacking. Multiple studies demonstrate students' critical thinking skills are low to middling (Alfitriyani et al., 2020; Mahanal et al., 2019; Yuliarti et al., 2023). According to data from the Global Creativity Index, Indonesia is placed 115th out of 139 nations (Florida et al., 2012). This data shows that Indonesia still lacks skills in creative thinking. Multiple studies previously demonstrated students' critical thinking skills are low to middling (Handayani et al., 2022; (Maniarta Sari et al., 2023; Utami et al., 2018).

Problems related to critical and creative thinking skills can be influenced by internal factors, namely students' abilities, and external factors, including the teacher's use of learning models and methods. The participation of other people and a supportive environment are really needed by students in forming and honing their critical and creative thinking skills. In the present epoch, educators must cultivate digital literacy to select the optimal environment for digital instruction and learning (Hall et al., 2014). In the digital era, it is necessary to address students' learning needs with innovative learning models due to the challenges associated with implementing traditional learning models (Gündüzalp, 2021). The use of appropriate teaching materials can accommodate students' critical and creative thinking skills (Septianti et al., 2022); (Khoiri et al., 2023). Student-oriented learning allows students to be more active, so it is regarded as a highly efficient method for refining and cultivating creative and critical thinking skills (Saputri et al., 2019).

According to the aforementioned survey results, these are general research results. Research on a smaller scope, specifically focusing on students' critical and creative thinking abilities when studying viruses in biology, needs to be carried out. The novelty of this study is the analysis of the initial profile of students' critical and creative thinking skills in biology learning, especially virus material, at a state senior high school in Madiun. The virus material was chosen because of its abstract nature, resulting in low student mastery of concepts, as well as difficulty in observing and studying the material (Adriani et al., 2019). These research findings can be utilized in the future to evaluate learning and enhance learning methodologies. The research aims to describe the preliminary study and conduct an analysis of the initial profile of students' critical and creative thinking skills in relation to virus material.

Method

The research carried out was quantitative descriptive research using test and questionnaire methods. The selection of the testing method in this study was made to describe the percentage of students who possess critical and creative thinking skills at a state senior high school in Madiun, East Java. Meanwhile, the questionnaire was used to collect preliminary study data regarding the level of difficulty experienced by students in studying virus material, learning methods, learning resources, and learning media, especially in biology subjects with frequently used virus material. The population used is class X students who have received virus material. A sample of 148 students was found using random sampling techniques, consisting of 74 students for the critical thinking skills test and 74 students for the creative thinking skills test. The test instrument used is an essay consisting of 20 critical thinking questions and 20 creative thinking questions. The sub-indicators of critical thinking skills that were proposed by Facione (2015) and creative thinking skills according to Torrance (1968) served as the basis for the development of instrument tests, which were adapted to virus material (Table 1 and Table 2). The developed test instruments and questionnaires were then validated by expert validators and tested using SPSS for the test instruments. After the test instruments and questionnaires were declared valid, they could be given

to students. The test instrument developed was then tested for validity and reliability using SPSS 25. Based on the validity test of critical thinking questions showed that a total of 20 questions were deemed to be valid and reliable, as demonstrated by a Cronbach's Alpha value of 0.733. Subsequently, the assessment of the creative thinking questions demonstrated that 20 questions were deemed valid and reliable, as shown by a Cronbach's Alpha score of 0.848. The final test scores of the students are utilized to determine their achievement of each critical and creative thinking skill indicator, which is then examined utilizing the Formula 1.

$$\text{Percentage (\%)} = \frac{\sum \text{total score obtained}}{\sum \text{maximum total score}} \times 100\% \quad (1)$$

Table 1. Integration of Critical Thinking Skills Sub-Indicators on Virus Material Questions

Indicators	Sub Indicators	Virus Material	Question Number
Interpretation	Categorize	Shapes of viruses	1
		Role of viruses	2
	Encoding data	Role of viruses	3
	Clarify meaning	Virus replication	4
		Role of viruses	5
Analysis	Testing ideas	Role of viruses	6
	Identify arguments	Characteristics of viruses	7
	Identify reasons and claims	Role of viruses	8
		Characteristics of viruses	9
Inference	Question statements	Role of viruses	10
	Alternative guess	Virus replication	11
	Draw logically valid conclusions	Role of viruses	12
		Virus replication	13
Evaluation	Assess the credibility of claims	Virus replication	14
	Assess the quality of arguments with inductive and deductive reasoning	Role of viruses	15
Explanation	State the results	Virus structure	16
	Explains the method	Role of viruses	17
	Putting forward an argument	Role of viruses	18
Self regulation	Self-check and correct	Role of viruses	19, 20

Table 2. Integration of Creative Thinking Skills Sub-Indicators on Virus Material Questions

Indicators	Sub Indicators	Virus Material	Question Number
Fluency	Answer with various answers	Virus structure	1
		Characteristics of viruses	2
		Classification of viruses	3, 4
	Provide various ideas on a problem	Virus replication	5
		Role of viruses	6, 7
Flexibility	Provide various interpretations of a problem	Shapes of viruses	8
		Impact of viruses	9
	Look for alternative ways to solve problems	Impact of viruses	10, 11
Originality	Providing a way or solution that is different from other people and is rarely proposed by many people	Role of viruses	12, 13
	Create different variations of parts or elements	Role of viruses	14, 15, 16
Elaboration	Developing and enriching an idea or thoughts	Role of viruses	17, 18
	Adding or elaborating in detail on an object, idea, or situation so that it is more interesting	Role of viruses	19, 20

Table 3. Interpretation of Critical and Creative Thinking Skills (Afriana et al., 2021)

Percentage (%)	Category
81 - 100	Very good
61 - 80	Good
41 - 60	Currently
21 - 40	Low
0 - 20	Very low

Result and Discussion

Preliminary Study

This stage included taking a questionnaire regarding the level of difficulty experienced by students in studying virus material, learning methods, learning resources, and learning media used, especially in the biology subject, virus material at a state senior high

school in Madiun. Analysis of the teaching materials used in biology learning about virus material was also carried out in a preliminary study. The teaching materials used at the school are biology textbooks.

The analysis of the preliminary study questionnaire revealed that 86.40% of pupils encountered difficulty in studying virus material. Some of the difficulties experienced include difficulty understanding complex and abstract material (which cannot be observed directly), many types of viruses making it difficult to understand, difficulty in analyzing the role of each virus, and difficulty understanding the process of virus replication and the process of its spread. Furthermore, regarding the use of learning methods by teachers, namely lectures methods (88.30%), question and answer (83.40%), group discussions (65.70%), presentations (52.40%), and practicum (36.80%). A graph of the percentage of learning methods used by biology teachers can be seen in Figure 1.

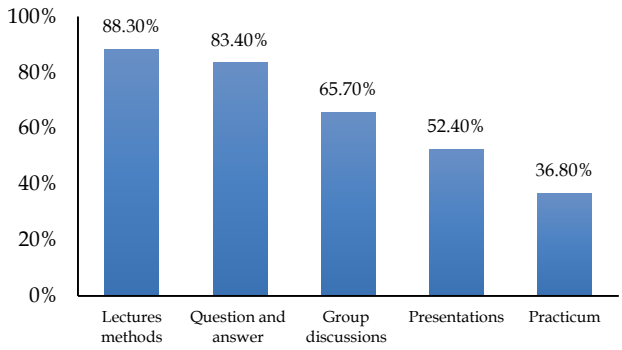

Figure 1. Percentage of learning methods used by biology teachers

The analysis of learning resources utilized in biology learning, especially virus material, are textbooks (89.30%), internet (61.20%), LKS (43.70%), and e-modules (9.40%). The majority of students stated that the learning resources used did not facilitate them in developing their knowledge regarding the material being studied. A graph of the percentage of learning resources used by students in virus material can be seen in Figure 2.

The next analysis shows that the type of media that teachers often use when teaching is PPT media (75.70%). Other learning media include videos (49.50%), print media (48.50%), images (40.80%), and e-learning (7.80%). According to the findings of the student questionnaires, it was stated that the media currently used still needs to be more interactive, so students tend to get bored when the teacher teaches the material. The graph of the percentage of learning media used by biology teachers on virus material is in Figure 3.

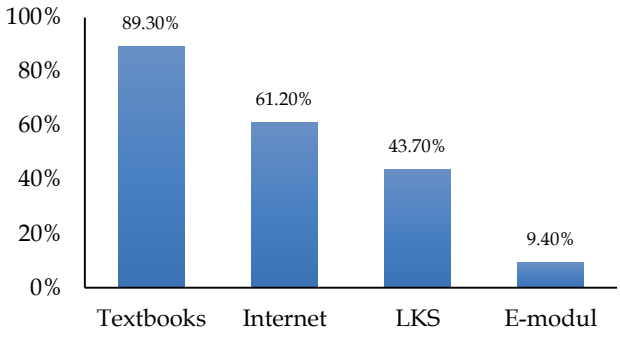

Figure 2. Percentage of learning resources used in virus material

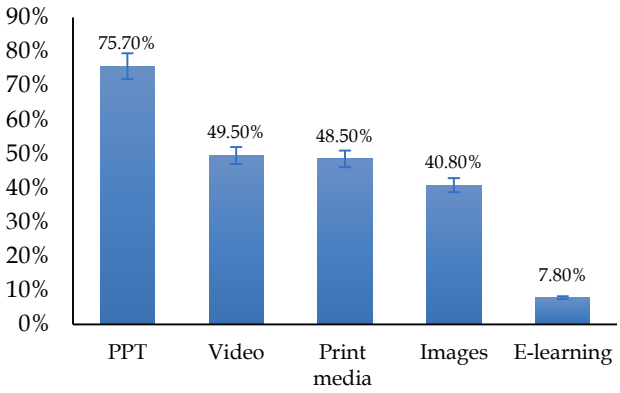

Figure 3. Percentage of learning media used in virus material

The findings of the analysis of the teaching materials utilized by teachers are in the low category to accommodate students' critical and creative thinking skills on virus material. The mean correlation percentage between critical thinking indicators in the biology textbook and virus material is 27.78%. Therefore, the book is still low in empowering students' critical thinking skills. Detailed data on the relationship between textbooks and critical thinking indicators is in Table 4. Meanwhile, the average percentage of links between creative thinking indicators in textbooks is 28.13%, so it can be concluded that these books are still low in empowering students' creative thinking skills. Detailed data on the relationship between biology textbook material on viruses and creative thinking indicators is in Table 5.

Table 4. Relationship between Textbooks and Critical Thinking Indicators

Indicators	Results (%)	Category
Interpretation	33.33	Low
Analysis	25.00	Low
Inference	33.33	Low
Evaluation	25.00	Low
Explanation	25.00	Low
Self regulation	25.00	Low
Average	27.78	Low

Table 5. Relationship between Textbooks and Creative Thinking Indicators

Indicators	Results (%)	Category
Fluency	37.50	Low
Flexibility	25.00	Low
Originality	25.00	Low
Elaboration	25.00	Low
Average	28.13	Low

Virus material is classified as material that poses a significant challenge to study in the context of biology lessons. The inherent complexity of the subject matter is a contributing factor to pupils needing assistance in comprehending the content of viruses. Previous research reported that 77.03% of students expressed that the virus material possessed learning components imperceptible to the unaided eye, exhibited a high level of content intricacy, and included several unfamiliar terms (Firmanshah et al., 2020). The next factor that causes students' difficulties in learning virus material is the teacher's way of teaching.

According to the findings of the analysis, 88.30% of the methods used by teachers in learning still use conventional methods, namely lectures. Students report that biology learning typically involves lectures provided in a teacher-centered style. Teachers' uncreative and monotonous way of teaching can result in students being less motivated to learn (Henriksen et al., 2017). Therefore, teacher competence and creativity are very important and necessary to increase students' enthusiasm and motivation in studying the material in biology lessons.

The research's analysis of the questionnaire data on learning resources indicated that 89.30% of students used school textbooks more often when studying virus material. Most students say that when solving a problem, they only focus on the textbook. Students are centered on the textbook, so students can only provide solutions to problems from one point of view. Students who only use textbooks as a learning resource tend to feel bored, saturated, and ineffective in the learning process, which hampers critical and creative thinking (Suciati et al., 2023). The learning process becomes effective if it utilizes teaching materials that support learning activities, such as modules or e-modules integrated with certain themes (Kurniawan & Syafriani, 2021).

Biology teachers frequently utilize PowerPoint media (PPT) as the primary learning tool for presenting virus-related topics based on the analysis results. The use of media only with PPT when teaching virus material is not said to be adequate for transferring knowledge to students (Harahap & Nasution, 2018). A teacher is required to be able to adjust the learning media used, making it easier for the teacher to deliver the material and attract students to learn, one of which is through interactive learning media.

The results of the study of teaching materials in biology textbooks, the virus material used as a reference during the learning process, is still categorized as lacking in training students' critical and creative thinking skills. So, the textbooks used do not show the existence of 21st century learning. Textbooks utilized in schools continue to fall under a general category of teaching materials, have yet to be presented in detail, and are still conventional.

Profile of Students' Skills in Critical Thinking

The research utilized 20 essay questions corresponding to the sub-indicators of critical thinking skills defined by Facione (2015). The test was conducted on 74 class X students at one of the Madiun State High Schools. Assessment is carried out based on student answers using a predetermined scoring rubric. The students' scores are calculated on a scale of 0-100 based on the ratio of their total score to the maximum score, multiplied by 100. The findings of the critical thinking skills analysis, which were derived from the scores of the students, may be found in Table 6.

Table 6. Recapitulation of Critical Thinking Skills Based on Student Grades (Supriyatno et al., 2020)

Value Range	Category	The Number of Students	Percentage (%)
> 81.25 - ≤ 100	Very critical	0	0
> 62.50 - ≤ 81.25	Critical	6	8
> 43.75 - ≤ 62.50	Less critical	25	34
≤ 25.00 - ≤ 43.75	Very less critical	43	58
Total		74	100

Table 6 shows data on critical thinking skills for each student in the biology lesson on virus material. According to the research, it is evident that a mere 8% of students are in the critical category. Most students fall into the very less critical category, with a percentage gain of 43%. As many as 25% of students fall into the less critical category.

The data about students' critical thinking skills, broken down by each indicator and sub-indicator, may be seen in Table 7. The table presents data regarding the percentage of critical thinking skills in the low category across six variables, with an average rate of 30.69%. The research's analysis of the critical thinking skills profile determined that students had not yet reached the optimal level. This finding lines up with other prior research that revealed that students in Indonesia still need to be more skilled in critical thinking (Benyamin et al., 2021; Rahmat et al., 2023). Several factors instigated

the students' low skills in critical thinking in this research, such as the method used by biology teachers in teaching virus material, which was still dominated by lectures. Applying the teacher-centered method can result in students feeling bored during learning. Preliminary study data support this and agree with the statement Sahyar & Yulia Fitri (2017) that students are less selective in solving the problems they face because the learning process is still teacher-centered. Monotonous and textbook-oriented learning makes students less motivated to learn.

Table 7. Percentage of Students' Critical Thinking Skills for Every Indicator

Indicators	Sub Indicators	Percentage (%)	Average (%)	Category
Interpretation	Categorize	30.74	32.23	Low
	Encoding data	31.08		
	Clarify meaning	34.29		
Analysis	Testing ideas	25.34	28.97	Low
	Identify arguments	33.11		
	Identify reasons and claims	28.72		
Inference	Question statements	35.47	30.08	Low
	Alternative guess	26.01		
	Draw logically valid conclusions	31.08		
Evaluation	Assess the credibility of claims	26.69	24.16	Low
	Assess the quality of arguments with inductive and deductive reasoning	21.62		
Explanation	State the results	38.18	33.56	Low
	Explains the method	37.50		
	Putting forward an argument	25.00		
Self regulation	Self-check and correct	34.29	34.29	Low
Average			30.69	Low

The next factor is the lack of students' level of accuracy when analyzing problems, the large number of students who are passive in group discussions, difficulty in working on C4-C6 type questions (analysis, synthesis, evaluation), students have difficulty connecting concepts with problems, and difficulty when expressing opinions during activities. discussion (Saputri et al., 2019). The trigger for low problem-solving abilities is also caused by teachers who only provide conceptual material but do not train students' critical thinking skills (Pradana et al., 2020). Another factor is the dearth of more learning resources integrated with indicators of critical thinking skills, which can hinder students from honing their skills.

Assessment of critical thought skills is essential, the objectives are: analyze students' critical thinking skills; provide feedback on students' critical thinking skills; and motivate students to become good critical thinkers (Nuraini, 2017). Students with critical thinking skills can process new information with their knowledge to deal with a situation. Critical thinking skills will shape students to process various information obtained with the knowledge they have to face conditions and situations (Rahmadani & Puti, 2021). Students who have received training in critical thinking will be adept at discerning between facts and opinions, correct and incorrect, and knowledge and belief. Solving complex daily problems requires critical thinking skills (Živkovil, 2016). Critical thinking skills significantly correlate with student learning outcomes, so empowerment is needed when these skills are still low (Supratman et al., 2023). Student's improvement of creative thinking skills relies on the foundation of critical thinking skills (Harjo et al., 2019). Students skilled in critical thinking can quickly develop new and innovative ideas to help face the era of globalization (Martincová & Lukešová, 2015).

Profile of Students' Skills in Creative Thinking

The research employed a test in the form of essay questions totalling 20 questions referring to Torrance's sub-indicators of creative thinking skills (1968). The test was conducted on 74 class X students at one of the Madiun State High Schools. The assessment is also the same when assessing critical thinking skills tests. The tabulated data for the calculation results, criterion for critical thinking skills, and number of students can be found in Table 8.

Table 8. Recapitulation of Creative Thinking Skills Based on Student Grades (Lely et al., 2020)

Value Range	Category	The Number of Students	Percentage (%)
75 < N ≤ 100	Very creative	0	0
50 < N ≤ 75	Creative	5	7
25 < N ≤ 50	Quite creative	55	74
0 < N ≤ 25	Less creative	14	19
Total		74	100

Table 8 presents information about the creative thinking skills of each student in the biology lessons, specifically about virus material. According to data analysis, the creative category comprises only 7% of students. Most students fall into the quite creative category at 55%, and 14% fall into the less creative category.

Data on the creative thinking skills of students in every indicator and sub-indicator are in Table 9. The table shows that students' creative thinking skills fall within the low group, with an average percentage of 32.88% across the four categories. Based on the data presented, it is known that students have not achieved the ideal score. This finding aligns with prior research demonstrating the need for Indonesian students to develop their creative thinking skills further (Risnanosanti et al., 2020; Sari et al., 2023; Sutanto et al., 2018). Several factors triggered the students' low creative thinking skills in this study. Especially in the way teachers teach, they still predominantly use the lecture method so that learning activities focus on the teacher, and students tend to be passive. Students demonstrate their capacity for creative thinking through accurate observation, analysis, and problem-solving (Permana et al., 2023). Based on the preliminary study analysis, the results showed that the media most often used in learning was PowerPoint, the learning resource students most often used were textbooks, and learning was still teacher-centered. So, this could cause a lack of development of students' creative abilities.

Table 9. Percentage of Students' Creative Thinking Skills for Every Indicator

Indicators	Sub Indicators	Percentage (%)	Average (%)	Category
Fluency	Answer with various answers	36.78	37.07	Low
	Provide various ideas on a problem	37.50		
Flexibility	Provide various interpretations of a problem	30.57	30.83	Low
	Look for alternative ways to solve problems	31.08		
Originality	Providing a way or solution that is different from other people and is rarely proposed by many people	35.47	35.68	Low
	Create different variations of parts or elements	35.81		
Elaboration	Developing and enriching an idea or thoughts	30.24	27.96	Low
	Adding or elaborating in detail on an object, idea, or situation so that it is more interesting	25.68		
Average			32.88	Low

If creative thinking skills are not trained during learning, it can result in students being less able to make assumptions and form decisions (Wojciehowski & Ernst, 2017). Students' less collaborative learning styles can have an impact on reducing students' learning skills (Laal & Laal, 2012). The restricted development of creativity is partly attributed to the learning system, which primarily focuses on fostering convergent thinking skills confined to logical reasoning and verbal analysis. Learning that combines the harmony of convergent and divergent thinking abilities can realize student creativity. If someone has good creative thinking skills, they will have more insight, high creativity, be able to innovate and implement new ideas in the outside community (Kim, 2019).

Students who are skilled in creative thinking are able to express themselves in various ways. Students should possess the capacity to apply their knowledge in real-life situations, especially in facing advances in the era of globalization (Sandika & Fitrihidajati, 2018). Students need creative thinking skills to face the era of globalization. This can be achieved by improving students' abilities to take the initiative to solve problems, especially in the development of science and technology (Al-Mahasneh, 2018). Students skilled in creative thinking can make it easier to find ideas and solutions to solve complex problems, whether they are questions in learning or everyday life. Agrees with the statement (Ulger, 2018) that creative thinking skills empower students to address their difficulties through innovative ideas, solutions, and responses. Creative thinking skills can help students' academic performance and success in personal and social life (Wechsler et al., 2017). Given the importance of creative thinking skills for students, it is necessary to empower them through the learning process, learning resources, or structured assignments that accommodate each indicator of creative thinking. There needs to be encouragement from a superior social environment to empower students' creative potential (Sitorus & Masrayati, 2016). Creative and active thinking can be improved through innovative learning activities.

Empowering Critical and Creative Thinking Skills through Learning Innovation

The importance of students' comprehension of creative and critical thinking skills in problem-solving is widely recognized. Therefore, efforts are needed to train these skills in students through appropriate teaching procedures and strategies. Empowerment of critical and creative thinking during learning activities can create better and more meaningful learning activities (Azizi-Fini et al., 2015). Designing educational strategies based

on learning styles is crucial in increasing students' creativity and critical thinking skills (Supratman et al., 2023). Implementing student-centered learning is an effective approach to enhancing students' critical and creative thinking skills so that when learning, the teacher only acts as a facilitator (Susilowati et al., 2018). Students' creativity and critical thinking can be empowered through learning, which develops their imagination by providing problem solving that offers various perspectives (Anazifa & Djukri, 2017). Conducive learning activities have a positive effect on improving students' critical and creative thinking skills (Nazhifah et al., 2023). Developing the thinking process in a learning process requires an approach, method or learning strategy that supports the thinking framework (Rahmat et al., 2020). Teachers must think about developing interactive, inspiring, challenging, not boring, and motivating learning, as well as implementing contextual learning to increase students' critical and creative thinking skills. Examples of innovative learning models encompass integrated STEM learning, STEAM, project-based learning, problem-based learning, open-ended learning, open-inquiry learning, resource-based learning, creative problem-solving, guided inquiry, blended learning, and various more (Ahmad et al., 2021; Anazifa & Djukri, 2017; Hikmah et al., 2023); Irwandi et al., 2024). Integrating learning models with existing teaching materials is one form of innovative development effort.

The 21st century learning involves more information and technology-based visualization, making learning activities more interactive and effective (Putrawangsa & Hasanah, 2018). Digital-based teaching materials can effectively stimulate and enhance the skills of students in critical and creative thinking if they are developed appropriately. For example, flash movie learning, digital comics, educational games, electronic modules, web-based learning, virtual laboratories, etc. which are equipped with audio, video, graphics, images, animation, films, interactive quizzes (Amri & Kartono, 2023; Sunaryo et al., 2020). Several innovative lessons from previous research such as project-based learning via traditional games (Khoiri et al., 2023), Flash Movie Learning Media with a SETS Vision (Amri & Kartono, 2023), Process Oriented Guided Inquiry Learning based E-Module (Septianti et al., 2022), Ethno-Stem Project-Based Learning (Sumarni & Kadarwati, 2020), STEM-Based E-Learning (Nazhifah et al., 2023), and others. It is hoped that the elaboration of learning methods, techniques and models with developments in science and technology can be utilized by teachers to create innovative learning.

Conclusion

According to the completed data processing, the results show that 86.40% of students have difficulty learning the virus material. The learning method that is often used is the conventional method or the lecturing method (88.30%), the learning resources that were often used were textbooks (89.30%) and PowerPoint (75.70%) as a frequently used learning medium. The correlation between biology textbooks and critical thinking indicators obtained results of 27.78% and 28.13% for creative thinking indicators. Based on research, it can be seen that students' critical thinking skills profile is low, with a percentage of 32.23% (Interpretation), 28.97% (Analysis), 30.08% (Inference), 24.16% (Evaluation), 33.56% (Explanation), 34.29% (Self-regulation). Meanwhile, the profile of students' creative thinking skills is classified as low, with a percentage of 37.07% (Fluency), 30.83% (Flexibility), 35.68% (Originality), and 27.96% (Elaboration). In accordance with the findings of this investigation, it is necessary to empower critical and creative thinking abilities through the development of innovative learning.

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Author Contributions

Conceptualization, O.H.S.; methodology, O.H.S.; software, O.H.S.; validation, S and S.S.; investigation, O.H.S.; data curation, O.H.S.; writing—original draft preparation, O.H.S.; writing—review and editing, S., S.S., and O.H.S; project administration, O.H.S. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest regarding publication of this paper.

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