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DEVELOPMENT OF A CRITICAL LEARNING MODEL TO ENHANCE STUDENTS' CRITICAL THINKING SKILLS IN BIOLOGY EDUCATION

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Abstract. The critical learning model is a learning model based on social constructivism. This study aims to develop a valid, practical, and effective learning model to improve students' critical thinking skills. The basis for the development of this learning model is that students are not actively involved in the PBL model because the problems are not relevant to students' lives, so the researcher developed a critical learning model that emphasizes the implementation of problems presented relevant to students' lives. This study uses the RnD research method, which refers to the ADDIE model. The research respondents included 2 expert validators, practitioners, and students of SMAN 9 Makassar. The development of the model produced a critical learning model syntax consisting of managing; directing; guiding and probing; explaining; and assessing; with purposive sampling at SMAN 9 Makassar class XII 5 Biology Interest. The results showed that the learning model met the validity criteria with a very high category (0.85), practicality with a practical category (83.98%), and effectiveness with a moderate category (0.67) so that the critical learning model is valid, practical, and effective in improving students' critical thinking skills. The results of field trials have proven that they can improve students' critical thinking skills.

Keywords: critical thinking, ADDIE development model, critical learning model, biology learning

INTRODUCTION

Education was the main foundation in shaping quality human resources, especially in facing the challenges of the 21st century. The 21st century was centered on the development of the Industrial Revolution 4.0, which places great importance on basic knowledge and skills as the main spearhead of the times. This 21st-century learning was expected to be able to open and expand opportunities and employment so as to form quality human resources in Indonesia. Therefore, the government continues to develop and renew the education sector and tries to overcome existing problems. One important aspect that needs more attention in the education sector is the learning plan and process while still paying attention to learning outcomes. Thus, a teacher was required to plan and prepare structured learning materials, which are certainly supported by learning models and methods that are in accordance with the needs of students.

Needs of learners in learning are very diverse because they are influenced by diverse abilities. One of the abilities of students in the 21st century that was classified as low was the critical thinking ability, communication ability, and collaboration of students. Based on the results of observations made at SMA Negeri

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9 Makassar, of the three abilities that are most in the spotlight and need to be improved quickly, namely the critical thinking skills of students. The data obtained in this field was in accordance with the research of Aji & Nugraheni (2023), which states that the critical thinking skills of high school and vocational school students in Indonesia were still in the low category.

Critical thinking skills were very important for students at all levels of education because these skills allow a person to analyze, evaluate, and solve problems effectively (Roza & Festiyed, 2023). According to Paillin et al., (2024), the ability to think critically was thinking by involving active, thorough, and rational considerations, while according to Fitriani et al., (2021), the ability to think critically was a person's ability to solve problems through the discovery of information obtained from facts that can be proven true. Some indicators of critical thinking are analyzing arguments, questions, and answers that arise, considering findings, making further explanations, and deciding on actions to be taken as solutions to problems (Salamah et al., 2023).

Various models had been applied to solve the problem of low critical thinking skills of students, one of which was the problem-based learning (PBL) model, but the application of this model has limitations, namely that students often find it difficult to determine problems according to students' thinking abilities, then the PBL model takes longer than conventional learning, and often in learning students are faced with difficulties because in problem-based learning students must learn to find data, analyze, formulate hypotheses, and solve problems (Amalia et al., 2023). The application of the second model to solve the problem of low critical thinking skills was inquiry-based learning, but the application of this model has limitations, namely, it was difficult to control student activities and success. Because students are given the freedom to explore topics, teachers may have difficulty in ensuring that all students are on the right track and understand the material being taught (Pramudya & Safrul, 2022).

Critical thinking skills were important in learning because they can improve problem-solving abilities so that students were invited to solve existing problems by evaluating the results obtained, encouraging someone to make the right decision, and helping students understand material concepts in depth (Hidayat & Nizar, 2021; Siagian et al., 2023). Therefore, a learning development model was needed that was in accordance with the problems faced while still paying attention to the needs of students. Innovations in learning models and methods that are focused on developing critical thinking skills and improving students' ability to solve problems need to be done. This is supported by learning that used to be centered on the teacher but was now centered on students.

Teachers now only act as facilitators who must be able to encourage creativity and ways to stimulate students in problem-solving so that problem-based learning models become increasingly relevant in facing modern challenges. To overcome this problem, innovation is needed in learning approaches that are specifically designed to stimulate higher-order thinking skills (Kwangmuang et al., 2021). One relevant solution is the implementation of the critical model, a structured learning approach to improve students' critical thinking skills.

The development of the critical model was a development model that we developed and can be one way to overcome the problem of low critical thinking of students. The critical learning model was problem-based learning with technology-integrated differentiation with a discovery principle approach. This model was developed by adjusting to existing problems that contain a series of activities that were actively involved in investigating real problems and practicing analyzing,

evaluating, and conveying the results of thinking logically and also getting relevant and meaningful learning experiences.

Similar research has also been conducted by Cahyani et al. (2021), which discusses improving critical thinking skills with the probem-based learning model. The study succeeded in improving critical thinking skills with the right learning model for 10th grade high school students. Likewise, the critical model also has an urgency in today's learning with the syntax of how students analyze problems and find solutions to problems supported by learning theory. Not only that, this learning model was based on the problem-based learning (PBL) model as well as discovery learning and inquiry learning. With the existence of models and learning theories that support it, it was hoped that students could improve their critical thinking skills.

According to Hermasyah (2020), students do not have interest or do not believe that the problems being studied are difficult to solve even before trying to find a solution to the problem. This is because the problems applied by teachers in problem-based learning models have not been integrated into real-life students so that students are reluctant to contribute to the learning process because the problems given are less relevant and meaningful. The difference in the critical learning model lies in the presentation of problems that are relevant to students so that all students are actively involved in learning. Based on the problems above, this study aims to develop a valid, practical, and effective critical learning model to improve critical thinking skills in class XII 5 students majoring in Biology at SMA Negeri 9 Makassar.

RESEARCH METHOD

This research method was carried out based on theory and the type of research and development (Research and Development). This research was carried out with the aim of obtaining results in the form of a learning model that has been proven effective in its application. Development research was carried out using the ADDIE development model with 5 main stages, namely: Analyze, Design, Develop, Implement, and Evaluate. The ADDIE method was chosen to be used in developing this learning model because it has systematic stages and the design always goes through revisions at each stage. We can move to the next stage if the first stage is deemed appropriate and there are no further things that need to be revised. Thus, it would be easier to develop a valid, effective and practical product.

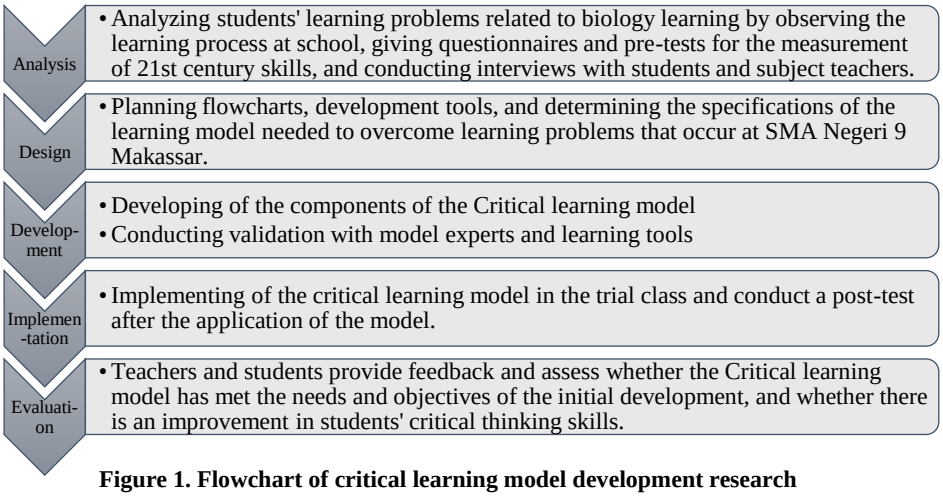

Figure 1. Flowchart of critical learning model development research

This research was conducted in the odd semester of the 2024-2025 academic year. The subjects of this study were students of class XII 5 Biology specialization at SMA Negeri 9 Makassar with 36 students. The research sample is purposive sampling because it is based on teacher considerations. Class XII students were selected after preliminary research was conducted based on the results of the 21st century skills questionnaire on students, especially critical thinking, communication and collaboration skills, analysis of students' cognitive development, interviews with teachers, observation of problems that occur in the learning process, analysis in the preparation and implementation of Teaching modules, and analysis of student learning needs and problems obtained through interviews and data obtained in the form of students' critical thinking skills which are in the very low category. Based on the results of the analysis of students' cognitive development, it was found that the average age of class XII students was in the range of 17-19 years. According to Piaget (Santrock in Azzahra et al. 2023), high high school students aged 17-19 years are experiencing a formal thinking period. The period of formal thinking is when adolescents can consider all possibilities to be able to solve a problem and take responsibility for it based on existing hypotheses so that it is very suitable for developing students' critical thinking skills.

Research instruments and data collection techniques were carried out using instrument sheets that have been validated by experts, including instruments for the validity of the critical learning model, instruments for the practicality of the critical learning model, as well as assessment sheets for students' critical thinking abilities. The validation results were then interpreted according to the level of validity of the learning model that follows Gregory's validity testing technique. Using expert assessment, then the assessment results were quantified. According to Gregory, the content validity calculation mechanism is then categorized as in Table 1.

Table 1. Content validation criteria according to Gregory

Validation Score Coefficient Interval	Criteria
0,8 - 1,0	Very high validity
0,6 - 0,79	High validity
0,4 - 0,59	Medium validity
0,2 - 0,39	Low validity
0,00 - 0,19	Very low validity

(Rosemawati et al., 2022)

The results of the model design, which had been validated by two experts in learning models and learning tools were then tested on students in the biology learning process at school. The data obtained was in the form of practicality assessment questionnaire data by teachers and students and then tabulated following the practicality assessment criteria provided in Table 2.

Table 2. Criteria for the level of practicality of the critical learning model

Practicality Criteria Interval	Criteria
86%-100%	Very Practical
76%-85%	Practical
60%-75%	Quite Practical
55%-59%	Less Practical
<54%	Impractical

(Aldi et al., 2022)

The results of the model design have been tested on students in the learning process and then pretest and posttest data on students' critical thinking skills are taken from the results of learning with the model developed. The data was analyzed using the gain score formula which was then matched with the criteria in Table 1 to see the validity aspect, Table 2 to see the practical aspect, and Table 3 to see the gain in students' critical thinking skills after learning using the critical learning model.

Table 3. N-Gain criteria for critical thinking skills with the critical learning model

N-Gain Sore	Categori
0,71 < N-Gain	High
0,31 ≤ N-Gain ≥ 0,70	Medium
N-Gain < 0,30	Low

(Hake, 1998 in Santhalia et al., 2024)

The implications of the critical learning model for students are that students are actively involved in the learning process so that they can improve students' critical thinking skills as a whole. With the application of this learning model, students' interest in the learning process also increases because the problems presented are relevant to life. While for teachers, this learning model can be a basic capital for teachers in developing themselves and increasing insight by studying problems that are relevant to students' lives to be applied to the critical learning model.

RESULT AND DISCUSSION

Data was obtained after carrying out research on the development of critical learning models which consists of the Analyze stage in the form of information gathering activities related to learning problems and needs in the field, the Design stage, which is the stage of designing the model and learning tools, the Develop stage where the model and learning tools are developed from the design stage which is ready to be implemented in the field. Implementation is the stage of implementing the learning model and tools in the school in this research at SMA Negeri 9 Makassar, and Evaluate stage was carried out to assess the quality of the product produced in terms of validity, effectiveness, and practicality.

The results of the analyze stage are preliminary studies, which include analysis of 21st-century skills in students, especially critical thinking skills, communication and collaboration, analysis of students' cognitive development, interviews with teachers, observation of problems that occur in the learning process, analysis in the preparation and implementation of Teaching Modules, as well as analysis student learning needs and problems obtained through interviews.

Data from the analysis of students' 21st-century skills at SMA Negeri 9 Makassar shows the value obtained from collaboration skills was 76.24%, communication skills were 71.93%, and critical thinking skills were 38.79. Based on existing data, the category of student collaboration and communication skills is "Medium." As for critical thinking skills, they are in the "Very Low" category.

Analysis of students' cognitive development showed that the average age of class XII students was in the range of 17-19 years. Considering cognitive development, it can be used as a guide for determining and developing learning models that will be used in the learning process. According to Piaget (Santrock in Azzahra et al., 2023), high school students aged 17-19 years are experiencing a

period of formal thinking. The formal thinking period is when teenagers can consider all possibilities to be able to solve a problem and take responsibility for it based on existing hypotheses.

Interviews conducted with Biology subject teachers and students at SMA Negeri 9 Makassar stated that the learning model that is often used is the direct learning model. The problems encountered include students considering Biology to be difficult, especially in certain material, students being less enthusiastic about following the learning process, having difficulty communicating in the academic aspect, preferring individual learning to group learning, lacking skills in asking further questions, and students' critical thinking skills are low and teachers still find it difficult to choose an appropriate learning model. This is because heterogeneous students have different learning styles.

The results of the field study obtained were then continued at the design stage to serve as a basis for designing material for developing learning models. The results of discussions with the team agreed to develop differentiated problem-based learning integrated with technology with a discovery approach. In this learning, students are invited to explore authentic problems or questions that are relevant to their lives. Then actively seek information, analyze data, and build understanding of concepts through an investigation process, then the results of their investigation are reported and presented in class in different forms. This concept is aimed at improving students' critical thinking skills. Students are trained to formulate questions, evaluate sources of information, present and explain the results of their investigations and are expected to be able to draw conclusions based on the supporting evidence that has been obtained. Thus, it was decided that the model plan to be developed would be named the critical learning model.

The next stage was the develop stage where the development of the critical learning model was developed based on the results of field studies and literature studies by following the steps of the ADDIE development model. The model development is constructivist in nature which is designed to involve students actively in the learning process, developed in biology learning and applied to genetic material which is supported by a prototype model (implementation guide). The learning tools include teaching modules, teaching materials, teaching media and evaluation instruments. The model development procedure is created by preparing a prototype. The results of model development can be seen in Table 4.

Table 4. Results of the development of the critical learning model

Theoretical basis	The theoretical basis that is the reference for the critical learning model is constructivist theory, behaviorist theory, humanism theory, Bandura's social theory, cognitive theory, Bruner's theory. Critical learning is developed by involving students to find solutions, improve understanding, reasoning and cognitive skills in a meaningful way.
Syntax	The critical learning model syntax includes six stages. These stages consist of 1) Managing; 2) Directing; 3) Guiding and Probing; 4) Explaining; and 5) Assessing.
Social Systems	The social system in the critical learning model describes the relationships and interactions that occur between teachers, students, and the learning environment during learning. The social system element in the critical learning model involves the role of the teacher as a facilitator who designs learning, provides stimulus, guides and evaluates student performance. Students act actively as learning subjects which emphasize aspects of responsibility, collaboration and developing arguments in presentations. Social interactions between teachers and students are participatory, dialogical and reflective. Relationships between students emphasize cooperation, discussion, and peer learning. The learning environment is designed to encourage freedom of thought, facilitate collaboration and provide resources to support

	investigations.
Reaction Principles	The reaction principle in the critical learning model describes how the teacher responds to actions, questions, or ideas that arise from students during the learning process. Teachers direct students in finding solutions through trigger questions, respect students' ideas, and create a comfortable learning atmosphere. Active participation is encouraged through discussion, high-level questions, and self-reflection. Teachers provide constructive feedback to strengthen students' arguments, present new challenges to stimulate critical thinking, ensure interactive, meaningful learning and support students to become independent and reflective learners.
Support System	The support system for implementing the critical learning model includes teaching modules, teaching materials for this material, namely genetics for class XII high school, teaching media in the form of (PowerPoint Presentation and learning videos) assessment grids, classrooms and biology laboratory rooms. The critical learning model is supported by an environment that must respond to the various demands of various learners. In this critical learning model, teachers and students must be able to collect whatever is needed when they need it. This is in accordance with Endedijk et al., (2022) opinion that feeling comfortable with teachers and other students can develop students' self-confidence and ability to express ideas and opinions.
Instructional Impact	The critical learning model includes improving critical thinking skills through structured activities. Instructional impacts include improving critical thinking skills, in-depth mastery of material, argumentation and communication skills, and problem-solving.
Companion Impact	The accompanying impact includes developing social skills such as cooperation and tolerance, increasing learning independence, creativity, self-confidence, positive character formation, and reflective abilities. This model not only achieves key learning objectives but supports the development of essential skills and attitudes for academic and real-life success, creating meaningful and sustainable learning.

The syntax of the critical learning model in the form of teacher and student activities and the underlying learning theory are explained in detail in Table 5.

Table 5. Syntax and learning activities of the critical learning model

Syntax	Teacher's Activities	Students' Activities	Learning Theory
Managing	At this stage, the teacher carries out learning planning and class arrangements so that the learning process is effective, starting with group division, explaining learning achievements, asking for feedback from students regarding the learning that will be carried out and the orientation of the learning process that will be carried out.	Students provide input and suggestions when the teacher conveys learning outcomes, arrange themselves to sit in groups to make it easier to carry out the next learning stage, students collaborate and communicate with each other, are more focused, easy to work with and are directed in their respective groups regarding the implementation of the learning process that will be carried out taking place.	• Behavioristic Theory • Constructivist theory
Directing	The next stage is for the teacher to briefly explain the initial concept in the form of material, trigger questions to determine the depth of students' understanding of the concept and provide further explanations related to learning instructions or assignments that will be carried out next, including instructions for making products to present events or phenomena (problems) that students find, the causes of occurrence and series of	Students at this directing stage discuss in groups to answer the trigger questions given by the teacher. Next, students carry out initial identification or background information on the problem found, explore the problem according to the learning material, and connect previous knowledge with the problem found for further investigation. The purpose of directing is to encourage	• Behavioristic Theory • Humanistic Theory

	solutions to problems.	students to find a problem in groups to be used in the next stage of guiding and probing.	
Guiding and Probing	Students at this directing stage discuss in groups to answer the trigger questions given by the teacher. Next, students carry out initial identification or background information on the problem found, explore the problem according to the learning material, and connect previous knowledge with the problem found for further investigation. The purpose of directing is to encourage students to find a problem in a practical way. Teachers guide and ask questions that stimulate students' thinking in each group. Teachers ask high-level questions that encourage analysis, synthesis, and evaluation and provide guidance to students who experience difficulties. Teachers also encourage students to explore ideas and solutions more deeply to solve the problems raised.	The results of students' searches at the directing stage will then be analyzed, processed and explored more deeply by students in order to practice critical thinking and analytical processes to search for and find their own answers to the problems raised. Students then present the background of the problem, causes of the problem, impact of the problem and resolution of the problem through various products that are ready to be presented, either in the form of infographics, illustrations, presentations, mind-mapping, etc.	• Constructivist Theory • Bandura's Social Theory • Cognitive Theory • Bruner's theory
Explaining	At this stage, the teacher acts as an observer and director if the discussion is at a deadlock or there are conceptual errors in the student's presentation.	In the explaining stage, students provide an explanation of the concept of the problem and the solution to the problem raised, then translate it into a different product depending on the product the student likes. The product is presented in front of the class by providing an explanation regarding the results of the analysis of problems found and concepts that students do not yet understand. In this stage, students are given the opportunity for open discussions to provide a clearer understanding.	• Bandura's Social Theory • Cognitive Theory • Bruner's theory
Assessing	The teacher carries out the assessing stage to see students' critical thinking abilities and learning outcomes by reflecting on the implementation of learning, providing feedback, and evaluating students' understanding by giving quizzes or formative assessments. Assessing student learning outcomes to ensure changes occur, namely knowledge, behavior, and skills, as well as the achievement of learning goals.	In the assessing stage, students listen carefully to the teacher's reflection on learning, answer reflection and enrichment questions, ask follow-up questions regarding material they have not yet understood, and answer well the assessment carried out by the teacher.	• Behavioristic Theory • Humanistic Theory

The social system in the critical learning model refers to the interactions and roles that take place during the learning process. This model adopts the principles of social constructivism, which describes the relationship of all learning components

during the teaching and learning process as a result of collaboration between individuals. The social framework of this model includes teachers, students, and the environment collaborating with each other in achieving learning goals with a focus on developing critical thinking skills.

The teacher as a facilitator, mediator, and guide in the critical learning model is very multifaceted as a supporter in the student learning process. Teachers as facilitators provide learning resources and encourage students' active involvement to create a supportive and enjoyable learning environment (Sulistriani et al., 2021; Gautam & Agarwal, 2023). Teachers as facilitators also reflect a paradigm shift in teaching approaches that emphasize student involvement and active learning (Endedijk et al., 2022).

The teacher, as a mediator, acts as an intermediary in student interactions, such as managing discussions and conflicts that arise during the learning process, both individually and in groups. The teacher's role as a guide is to have the responsibility to support student development through pedagogical and psychological guidance as well as learning evaluation demonstrated through discussions, investigations, and presentations (Sanjani, 2020).

Students as the main subject in learning means being actively involved in planning and evaluating learning; this is in line with the philosophy of cognitivism, which prioritizes the process of developing students' potential in solving problems. Students collaborate to analyze, evaluate, and draw conclusions from problems and convey their ideas and thoughts logically (Dinh & Nguyen, 2022).

Social interaction between teachers and students, collaborating in developing learning goals and strategies. In the dialogic stage, the teacher and students build discussions to ensure that students can understand and solve problems. In the reflective stage, teachers and students reflect on the results of the investigation to improve the learning process in the future (Ikadarny et al., 2023). Relationships between students in the critical learning model emphasize collaborative group work to identify, analyze, and develop solutions to problems. Students discuss to defend logical and critical arguments, as well as build interaction between students to share ideas, criticize and reconstruct thoughts (Hermaliani et al., 2024). The learning environment in the critical learning model creates freedom of thought to create an inclusive learning atmosphere. Arrangement of learning places to create interaction and provide learning materials that are relevant to learning (Badri & Azisi, 2024).

The reaction principle is a guide for teachers in responding to students' work, either through questions, responses, or in managing classroom situations in general. Teachers can provide responses in two forms, namely verbal and nonverbal. Verbal responses involve conveying responses verbally or in writing, while nonverbal responses are conveyed through hand movements, facial expressions, eye movements, or voice intonation (Akram et al., 2022).

This principle also reflects the way teachers view, behave, and respond to student behavior, as well as how students respond to teacher instructions and attitudes during the problem-based learning process (Uliyandari et al., 2021). One of the teacher's roles is to ask questions that can encourage students to think critically and ask their own questions. This process gives students the freedom to explore their questions, find answers, and formulate follow-up questions. In this case, the teacher acts as a facilitator and good questioner, helping students find possible answers while still encouraging independent thinking (Sanjani, 2020).

Teachers assess and respond based on the critical thinking processes demonstrated by students, not just factually correct answers. During the lesson, problematic situations are presented. Students are guided to learn to develop

knowledge and problem-solving skills. Students study with groups so that the information they obtain can be meaningful for themselves (Rusmin et al., 2024). Teachers respond by providing space for students to take initiative in their learning. Responses are provided in the form of guidance or feedback to help students find answers on their own, rather than providing immediate solutions.

Instructional impact was the main learning outcome that was directly expected from implementing the critical learning model. This impact includes the achievement of planned learning objectives, such as improving critical thinking skills, where students are trained to identify problems correctly, analyze information or data systematically, evaluate arguments and evidence based on logic, and make rational and evidence-based conclusions (Wahdaniyah et al., 2023). Critical thinking is used to train students to be able to think deeply, critically and imaginatively, use logic, analyze facts and generate imagination based on local and traditional ideas. So that students can differentiate between good and bad thinking (Muhibbuddin et al., 2019). Deep dialogue and critical thinking aim to gain the most complete understanding. Through in-depth dialogue and critical thinking, students understand how they relate to other people and their environment. Critical thinking helps students identify and test their own attitudes, as well as appreciate the values they are learning (Hidayat & Nizar, 2021).

Mastering subject matter through investigations, discussions, and presentations, students can understand learning concepts in depth. Learning does not only focus on memorization, but also on integrated conceptual understanding (Basri et al., 2019). The importance of applying real contexts in learning helps students link theory with practice. The critical learning model has proven to be effective in increasing mastery of subject matter in depth and applicability.

The argumentation and communication skills found at the presentation stage, students learn to convey their ideas or analysis results in a clear, structured, and logical manner, which supports academic communication skills. Students' problem solving abilities in the critical learning model in question are able to identify solutions to real problems given in the learning process, utilizing their knowledge to deal with complex situations (Agung et al., 2022).

Accompanying impacts are additional learning outcomes that may not be directly planned, but arise as a consequence of the learning process in the critical model. In several models, especially problem dialogue and critical thinking, it includes increasing self-confidence, creativity and problem-solving abilities. The development of social skills is an important aspect of the child's development process. One aspect of development that needs to be developed in early childhood is social skills. Children's success in starting interactions and adapting to the surrounding environment is very important (Sørlie et al., 2021). Social skills include behavior, attitudes, and actions that a person shows when interacting with people in the surrounding environment (Sari, 2024). The importance of developing social skills for students today needs to be integrated into the learning process, so that routine educational activities can encourage students to work together to solve problems and find solutions effectively (Mishra, 2023).

Increased learning independence through independent investigation, students become more confident in searching for information and solving problems independently, without relying too much on the teacher. This process teaches students to be responsible for their own learning. By clearly defining tasks and responsibilities, students can be more actively involved in the learning process and develop effective self-evaluation skills (Li, 2023).

Students were trained in creativity and innovation to think outside the box in devising creative solutions to given problems. In the context of 21st-century education, creativity and innovation play a very important role and cannot be ignored (Anagün, 2018). Education today focuses on developing creative skills that enable students to see the world from different perspectives and find new solutions to problems. A learning process that involves real problem solving can stimulate student creativity and innovation. Apart from that, the critical thinking process plays a role in producing new ideas that are more innovative and applicable (Hasanah et al., 2023).

Strengthening self-confidence, presentation of investigation results helps students build confidence in public speaking. In addition, students become more confident in their own ability to analyze and make decisions. Creating a conducive learning atmosphere and involving students in decision making can increase their self-confidence. Emphasis on a positive self-concept is also the main key in building strong and sustainable self-confidence (Hayudinna & Muzkiyah, 2024).

Formation of positive character, where character education plays an important role in forming students' positive attitudes towards learning. Through a process of investigation, discussion, and reflection, students can learn and internalize values such as honesty, intellectual integrity, and academic responsibility. School, after family, is an effective place to shape a child's positive personality. The character habituation process at school includes the ability to assess oneself, accept responsibility, and control emotions wisely (Waruwu, 2024).

Reflective abilities make students accustomed to reflecting on what they have learned, how they learned, and how they can improve their thinking processes in the future. Students with high reflective thinking abilities tend to be better at controlling their learning process, and are able to solve problems more effectively (Putra et al., 2024). The application of the critical learning model not only produces instructional impacts in the form of achieving designed learning objectives, but also accompanying impacts that help students develop skills, attitudes and character that are essential for success in the academic world and real life. Thus, this model becomes a comprehensive learning approach to create meaningful and sustainable learning with a focus on improving students' critical thinking skills (Rediani, 2022).

The critical learning model that has been developed is then carried out in the validation stage by two experts in biology learning models and tools. The results of the validity analysis of the critical learning model can be seen in Table 6.

Table 6. Analysis of validation of critical learning model learning experts

No.	Validated Aspects	Coefficient	Criteria
1	Supporting Theories	0.83	**Very high validity**
2	Syntax	0.88	**Very high validity**
3	Social Systems	0.88	**Very high validity**
4	Reaction Principles	0.90	**Very high validity**
5	Support System	0.80	**Very high validity**
6	Instructional and Accompanying Impact	0.86	**Very high validity**
7	Implementation of Learning	0.87	**Very high validity**
8	Learning Environment and Management Tasks	0.80	**Very high validity**
9	Evaluation	0.80	**Very high validity**
	Average Validity	**0.85**	**Very high validity**

The validation results of the critical learning model by two experts in biology learning models and tools obtained an average validity result of 0.85 with very high

validity criteria. At the validation stage, the material validator tests the quality of the learning model which consists of nine supporting aspects such as supporting theories, syntax, social systems, reaction principles, supporting systems, instructional impact and accompaniment, learning implementation, learning environment, and evaluation. The validity of the learning model is seen from the validation results by expert validators who provide feedback in the form of comments and suggestions until the model is said to have very high validity by both expert validators of the model and learning tools, which is in accordance with the opinion of Mokodompit et al., (2024), which states that whether a learning model is valid or not can be determined through expert validator feedback. This shows that all the components presented in the critical learning model are suitable for use in the teaching and learning process in terms of nine supporting aspects. Therefore, it can be concluded that the supporting aspects in the critical learning model have very high validity in supporting the teaching and learning process and are applied in learning to overcome students' low critical skills. This is in line with what Widyastuti & Susiana (2019), said that a learning model is said to be valid if all its components are declared suitable for use.

After being declared valid, the critical learning model was then carried out in the Implementation stage in class XII 5 Biology Specialization at SMA Negeri 9 Makassar. The application of the learning model was carried out by teaching practitioners and assessment results were obtained from teachers and students in the form of the practicality and effectiveness of the critical learning model. The results of the practical analysis of the critical learning model by teachers and students sre provided in Table 7.

Table 7. Practicality analysis by teachers and students of the critical learning model

No.	Statement	Percentage (Criteria) Teacher Response	Percentage (Criteria) Student Response
1	Student Engagement	80.00% (practical)	85.78% (practical)
2	Resource Availability	80.00% (practical)	83.33% (practical)
3	Ease of Implementation	80.00% (practical)	85.78% (practical)
4	Relevance to the Curriculum	84.40% (practical)	87.33% (very practical)
5	Skills Development	80.00% (practical)	83.67% (practical)
6	Teacher Support and Training	82.20% (practical)	87.78% (very practical)
7	Ratings and Feedback	86.67% (very practical)	87.11% (very practical)
8	Connection with Everyday Life	80.00% (practical)	88.00% (very practical)
9	Student Motivation and Enthusiasm	81.67% (practical)	87.83% (very practical)
Average Teacher and Student Practicality Response Score		**83.98%**	**Practical**

According to Cahyani et al., (2021), a learning model is said to be practical if the validator states that the critical model can be used with little or no revision. The method used to provide a practical assessment of the critical learning model is by providing a questionnaire regarding practical assessment to teachers and students. Based on the results of observations made by filling out practicality questionnaires by teachers and students regarding the critical learning model, the results obtained were 83.98% with practical criteria which shows that the critical learning model can be used in the learning process in the classroom. This conclusion was drawn from the results of the teacher's experience during the implementation of the learning model which was carried out in accordance with the technical instructions and steps

in the learning module that had been designed. This is in line with the opinion of Lantowa et al., (2022) which states that the practicality of implementing learning is assessed based on observations, namely that learning can be carried out well in accordance with what is stated in the technical instructions and teaching modules.

The critical learning model is said to be specifically practical because it can support students to think critically in the classroom. Kwangmuang et al., (2021) states that critical thinking aims to examine a condition, all available information, and significantly verify and integrate conclusions, questions, phenomena, or problems to obtain a hypothesis. The critical learning model can support student involvement in the classroom and increase student motivation and enthusiasm in the teaching and learning process so that learning takes place effectively and actively. Not only that, the critical model is also easy to implement in the classroom, relevant to the applicable curriculum, related to students' daily lives so that students can implement it in their lives, and can provide resources. The critical learning model also focuses on the availability of resources, teacher support and training, and the resulting assessment and feedback.

The effectiveness of the critical learning model was seen in increasing the value of students' critical thinking skills before and after implementing the learning model. The value of students' critical thinking skills before and after the application of the critical learning model can be seen in the following graph.

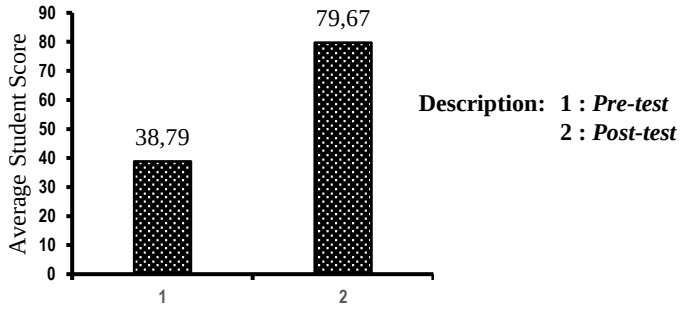

Figure 1. Graph of pre-test and post-test results of critical thinking skills of students in class XII 5 Biology specialization of SMA Negeri 9 Makassar

The results of the analysis of the effectiveness of the critical learning model on improving students' critical thinking skills can be seen in Table 8.

Table 8. Analysis of the effectiveness by teachers and students of the critical learning model

Pre-test Average	Post-test Average	N-Gain	Categori
38.79	79.67	0.67	Medium

The average value obtained from the N-Gain score was 0.67, which if categorized was in the “Moderate” category. It can be said that the application of the critical learning model effectively improves the critical thinking skills of students in class XII 5 Biology specialization at SMA Negeri 9 Makassar. Analysis of the value of students' critical thinking skills was carried out by testing the gain score. Gain score testing uses pretest average data of 38.79 and posttest average data of 79.67. The pretest and posttest data processed are data obtained from the trial class. The gain score test was conducted to determine the percentage of the

effectiveness of the developed learning model. This data shows that the average students who reached the level of completeness in the initial test (pre-test) was very low. Elbyaly & Elfeky (2023) stated that one of the learning objectives was to develop critical thinking. Teaching strategies that encourage students to actively participate in the learning process, such as problem solving programs, increase their desire to participate. However, after learning activities with critical learning models, there is a significant increase in students' critical thinking skills The result of the gain score test obtained is 0.67 with a Medium category. According to Paillin et al. (2024), the effectiveness of a learning model can be obtained from the N-gain value derived from the pretest and postest scores. Based on the N-Gain test table, the average obtained is 0.67 which is included in the moderate category. This means that the use of critical learning models in learning effectively improves the critical thinking skills of students in class XII 5 Biology Specialization of SMA Negeri 9 Makassar.

Overall, the research has been carried out in accordance with research procedures using the ADDIE development model. The research was in accordance with the research objectives, namely developing a valid, practical and effective Critical learning model to improve critical thinking skills in students of class XII 5 Biology specialization at SMA Negeri 9 Makassar. After the process of developing and testing the model in the field, data in the form of validity with a value of 0.85 very high validity category obtained based on the assessment of 2 expert validators after the analyze, design, and development process where at each stage discussions and evaluations are carried out to obtain optimal results. Practicality data with a value of 83.98% in the practical category and effectiveness data with a value of 0.67 in the moderate category were obtained after the model was declared valid which was then carried out in the next stage in the form of implementation following the stages of the ADDIE development model.

CONCLUSION

The description of the research described above can be concluded that the development of the critical learning model begins with analyzing student learning needs, compiling the syntax of the learning model, and adjusting the instructions used to facilitate the use of the model. Then, the critical learning model developed meets the validity criteria with a very high validity category, practicality criteria with practical categories and effectiveness seen from the gain score is categorized as effective. Based on these three criteria, it means that overall there is an increase in students' critical thinking skills before and after using the critical learning model. The results of the field trial of the critical learning model show that this model is proven to be able to improve students' critical thinking skills, so it can be applied well in future biology learning situations. Students showed active involvement in discussions and group work, and supported each other to achieve common learning goals.

The application of the model carried out in the trial class still encountered several obstacles in its application. Aspects of improvement in future research can discuss related to the integration of models with technology-based teaching media, as well as material content that is presented more interestingly and interactively can further maximize the critical learning model that has been designed. Furthermore, the author hopes that this model is not only implemented in the context of biology learning, but can also be further studied in relation to various subjects and materials that are relevant to the implementation of the model.

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