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Development of a 4C skills evaluation instrument for biology: A validity and reliability study on Indonesian high school students learning

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Abstract

Students need to be proficient in the 4C skills of the twenty-first century (critical thinking, creative thinking, collaboration and communication). However, field conditions are out of step with 21st-century advancements. It is well known that high school biology teachers in Kerinci Regency have never particularly established programs to help students understand the 4C skills. The objective of this study is to develop instruments for measuring 4C abilities in biology learning to help biology teachers apply 4C skills-oriented learning in the class. The instruments developed are: 1) an instrument for evaluating critical thinking abilities in the form of essay questions with a grading rubric. 2) An instrument to evaluate creative thinking skills in the form of questionnaires and essay questions with grading rubrics. 3) An instrument for evaluating collaboration skills in the form of questionnaires and observation sheets. 4) An instrument for evaluating communication skills in the form of questionnaires and observation sheets. Assessment instrument experts, biology education practitioners and high school students from Kerinci Regency, Indonesia were included in the study. Empirical and content validations are used to validate instruments. Instrument reliability also covers the consistency of the validators in filling out the validation form as well as the empirical reliability of the instrument. The research findings indicate that the 4C skills assessment instrument is both valid and reliable. The 4C skills assessment instrument can be used to examine students' 4C skills in biology subject.

Keywords: Collaboration skills, Communication skills, Creative thinking skills, Critical thinking skills, Essay questions, Observation sheet, Questionnaire.

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1. Introduction

Twenty-first-century students need a variety of skills in order to succeed and compete. Students can use these skills both within and outside of the classroom (in daily life). Students today require critical thinking, creative thinking, collaboration and communication skills [1-3] also known as the 4C skills of the twenty-first century. Thinking is essential for humans since the quality of life and what is generated, constructed or made are determined by the quality of their thoughts. Students require critical thinking abilities to examine, draw conclusions through reasoning, assess or evaluate and make decisions or solve problems [4]. Bloom's Taxonomy divides critical thinking skills as analysing (C4), evaluating (C5) and creating (C6) [5, 6]. Critical thinking skills are consistent with educational goals. The objective of education is to be able to use information not just for memorization but also for problem-solving and decision-making [7]. This demonstrates the significance of critical thinking skills in biology education.

Creative thinking is widely recognised as an important aspect of learning. The need for modern problem-solving solutions emphasises the relevance of creative thinking skills [8]. The primary provision for innovation is creative thinking skills [9-11]. Students' essential capital for dealing with complex environmental difficulties is effective creative thinking abilities [12, 13]. People's survival and growth in the twenty-first century will require creative thinking skills [14].

Collaboration skills can impact students' innovative thinking [15]. Collaborative problem-solving frequently outperforms the performance of those working by themselves [16]. Collaboration skills are important not just for learning but also for solving real difficulties [17]. Working with others is a talent that will make life simpler. Collaboration is a valuable skill for students [2].

Communication abilities are most typically associated with collaborative skills [18-21]. Communication is the foundation for enhancing students' collaborative abilities [21]. Communication abilities are related to creative thinking and collaborative skills in students [22]. Communication is the most important instrument that humans use to adapt to their surroundings. Instructional strategies emphasising mastery of a number of abilities particularly communication skills are among the twenty-first century reforms [1, 2]. Communication skills allow people to communicate and evaluate ideas [23]. It is the most vital aspect of human life.

Researchers attempted to distribute questionnaires and conduct interviews with biology teachers in 14 high schools in Kerinci Regency (14 biology teachers) in preparation for the adoption of 4C skills-oriented learning in January 2022. According to the findings of the study, teachers were aware of 4C skills but had never designed learning specifically for them. The teacher highlighted how numerous activities at school had resulted in the 4C skill indicators. This suggests that teachers use 4C skills implicitly in the classroom but there are no instruments that teachers use to assess students' 4C skills.

Teachers must have assessment instruments as their major teaching tools. However, the creation of assessment instruments is still not perfect in some circumstances. Several evaluation forms or scoring rubrics still contain double-meaning terms such as some, enough, some of and so on. The phrases "maybe," "usually" and "sometimes" in Greenstein's [24] creativity grading rubric are one example. These terms muddy the scoring metric, lowering data accuracy or study bias. It is critical to use suitable and appropriate language to describe the student's situation.

A variety of instruments such as the Self-Assessed Collaboration Skills (SACS) [25], the Interpersonal Communication Competence Scale (ICCS) [26] etc. have been created by professionals. However, it should be highlighted that numerous criteria determine whether or not the instrument is appropriate for use in the classroom by teachers. Cultural bias is a common issue when using foreign or international instruments [27] particularly in Indonesia which has a varied culture. Some foreign evaluation measures may not perform properly in the Indonesian learning setting [28]. As a result, the objective of this study is to create a valid and reliable instrument for measuring students' 4C skills in biology learning for Indonesian high school students especially those in Kerinci Regency.

2. Literature Review

2.1. Critical Thinking Skills

Critical thinking skills highlight assertions or viewpoints with compelling arguments. Students use critical thinking when they examine other people's perspectives and interpretations [7]. Critical thinking includes actions beyond basic learning such as analyzing, evaluating and creating [5]. Critical thinking is associated with the actions of asking essential questions, analyzing evidence for ideas, reasoning about difficulties both logically and objectively and clearly and precisely expressing ideas and conclusions [29].

According to the Department for Education and Skills UK [6], critical thinking skills are defined by Bloom's Taxonomy at the levels of analyzing, evaluating and creating. According to Anderson and Krathwohl [30], thinking critically about a topic necessitates some conceptual knowledge at the level of analyzing, evaluating and creating. Table 1 explains Bloom's taxonomy in detail at the levels of analyzing, evaluating and creating. Hariyanto, et al. [31]; Muhlisin, et al. [32]; Nuraini [33] and Rahmatika, et al. [34] created a critical thinking skills instrument in Indonesia in the form of essay questions with various indicators of critical thinking skills, materials and application locations.

Table 1.
Bloom's taxonomy at the analyzing, evaluating and creating levels.

Bloom's taxonomy levels	Description
1. Creating (C6)	Organizing elements to make a cohesive or functioning whole and rearranging elements into a new pattern or structure.
2. Evaluating (C5)	Making judgments based on criteria and standards.
3. Analyzing (C4)	Partitioning materials or elements and identifying how the components relate to one another as a whole.

Source: Anderson and Krathwohl [30].

2.2. Creative Thinking Skills

The metacognitive process of making new associations that improve problem-solving, formulate plans or create distinct patterns, structures or products may be characterized as creative thinking [35]. Thinking creatively entails and results in something original or novel [36]. Combining or extending prior knowledge and abilities is creative thinking [15]. Associating and combining ideas is the process of creative thinking. Mumford, et al. [9] found that encouraging people to use associational knowledge increased both the quantity and quality of ideas produced. The development of creative thinking is a social and cooperative phenomenon that results from interpersonal interactions [36-38]. The instrument for developing creative thinking skills in this research refers to the indicators of Greenstein [24]. According to Greenstein [24], there are eight indicators of creative thinking abilities. Table 2 provides a detailed explanation of each indicator.

A creative thinking skills instrument was developed in Indonesia by Iwan, et al. [39]; Syamsiara, et al. [40] and Putri, et al. [41] in the form of essay questions with different indicators of creative thinking skills, materials and application locations. These differences can cause bias if they are applied or used in different places with different cultures. Specific creative thinking instruments are needed related to field conditions and regional culture, in this case, the student situation and culture of Kerinci Regency High School students as research subjects.

Table 2.
Indicators of creative thinking skills.

Indicators of creative thinking skills	Details
1. Curiosity	Interest in specific aspects or materials, new ideas and an active search for new concepts.
2. Fluency	Ability to observe things from many perspectives, explain diverse objectives and convey varied goals to others.
3. Originality	Ability to generate several ideas, create new products and properly convey them.
4. Elaboration	Capacity to improve something by adding details to it.
5. Flexibility	Ability to adapt easily to new situations and perceive various possibilities in everyday life.
6. Divergent	Ability to integrate, modify, adapt and reorganize previously thought-of ideas.
7. Messiness and risk-taking	The excitement of attempting new things and not being concerned about making mistakes.
8. With others	The excitement of attempting new things and not being concerned about making mistakes.

Source: Greenstein [24].

2.3. Collaboration Skills

All human service techniques and systems are built on collaboration [42]. Collaboration allows for the exploration of varied ideas and experiences through discussion [43]. Collaborative problem-solving frequently outperforms the performance of those working alone [16]. Collaboration presumes partnership and acknowledgment of all team members' talents and competencies [42]. The instrument for developing collaboration skills in this research refers to the indicators of Hinyard, et al. [25]. Hinyard, et al. [25] proposed a number of collaboration skill indicators which are shown in Table 3. A collaboration skills instrument was developed in Indonesia by Agustin, et al. [44] and Ilma, et al. [45] in the form of questionnaires and observation sheets with different indicators of collaboration skills and application locations.

Table 3.
Collaboration skills indicators.

Collaboration skills indicators	Details
1. Contribution	Regarding the ability to exchange resources (Ideas, resources and information) among people.
2. Team support	Openly supports team performance.
3. Team dynamics	Capable of measuring one's effect on the team and understanding team dynamics.
4. Interactions with others	Regarding knowledge of team interactions and appreciation for the contributions of other team members.
5. Role flexibility	Capable of positioning oneself as a team member or team leader.

Collaboration skills indicators	Details
6. Motivation and participation	Relating to how much participation is there in the team.
7. Quality of work	Always reflect on your best efforts.
8. Time management	Ability to use time well.
9. Preparedness	Readiness to start a job.
10. Reflection	Conduct self-reflection following team activities regularly.
11. Team learning	Seek feedback from team members.

Source: Hinyard, et al. [25].

2.4. Communication Skills

Communication skills emphasize empathy and helping relationships [46]. Communication consists of two processes: listening and speaking. The listening process is seen as a collection of interconnected components that may be recognized, evaluated and improved. The second phase is speaking which results from successful listening. People listen to others and then respond by comprehending, analyzing, interpreting and assessing their perspective [47]. The instrument for developing communication skills in this research refers to the indicators of Rubin and Martin [26]. Rubin and Martin [26] proposed communication skills indicators which are included in Table 4. A communication skills instrument was developed in Indonesia by Agustin, et al. [44] and Hikamah, et al. [48] in the form of observation sheets with different indicators of communication skills and application locations.

Table 4.
Communication skills indicators.

Communication skills indicators	Details
1. Self-disclosure	Ability to communicate with others and reveal or open oneself.
2. Empathy	An aspect of identification that involves understanding other people's feelings.
3. Social relaxation	A lack of fear or anxiety in regular dealings with others.
4. Assertiveness	Ability to uphold one's rights without rejecting those of others.
5. Altercentrism	Demonstrates interest in others and a focus on what they have to say.
6. Interaction management	The ability of a person to organize the phases of dialogue in routine conversations.
7. Expressiveness	Capacity to express feelings non-verbally through appropriate speech modulations, expressive gestures, posture corrections and distinct facial expressions.
8. Supportiveness	Descriptive (Rather than evaluative) affirmations about oneself or others.
9. Immediacy	Demonstrate that they are approachable and open to conversation.
10. Environmental control	The ability of a person to attain set goals.

Source: Rubin and Martin [26].

3. Methodology

This type of study is classified as development research focusing on validity and reliability studies of product development. Development takes place between January 2022 and January 2023. The instruments developed are: 1) instrument for evaluating critical thinking abilities in the form of essay questions with a grading rubric. 2) An instrument to assess creative thinking skills in the form of questionnaires and essay questions with grading rubrics. 3) An instrument for assessing collaboration skills in the form of questionnaires and observation sheets. 4) An instrument for evaluating communication skills in the form of questionnaires and observation sheets. Table 5 shows the developed product specifications.

Table 5.
Developed product specifications.

No	Variables	The form of the instrument	Validation type
1	Critical thinking skills	Essay questions are accompanied by a scoring rubric based on Bloom's Taxonomy as revised by Anderson and Krathwohl [30].	Content and empirical validation
2	Creative thinking skills	Creative thinking skills questionnaire referring to Greenstein [24].	Empirical validation
		Essay questions are equipped with a scoring rubric based on Greenstein [24].	Content and empirical validation
3	Collaboration skills	The collaboration skills questionnaire refers to Hinyard, et al. [25].	Empirical validation
		The collaboration skills observation sheet refers to Hinyard, et al. [25].	Content validation
4	Communication skills	The communication skills questionnaire refers to Rubin and Martin [26].	Empirical validation
		The communication skills observation sheet by Rubin and Martin [26].	Content validation

This research uses both content and empirical validity to support its conclusions. Two assessment instrument experts (minimum criteria for Ph.D. graduates in education) and two biology education practitioners (Biology teachers at Senior High School 3 Kerinci and Senior High School 11 Kerinci) validated the contents of the assessment instrument and

students from Senior High School 3, 11, Islamic Senior High School 1, 2 and 3 Kerinci participated in empirical validation. A validation sheet is used for content validation. The validation sheet for the contents of the 4C skills assessment instrument contains several assessment aspects which are presented in Table 6.

Table 6.
Assessment aspects in the development of 4C skills assessment instruments.

No	Validation instrument	Rated aspect
1.	Instrument for evaluating critical and creative thinking skills in the form of essay questions.	a. Each learning objective was represented by the test. b. There are clear instructions on how to take the test. c. The question sentences are well-structured and clear. d. The question words and directives are not all the same. e. The test has been properly designed. f. The test has been designed with communicative sentences. g. Tables, images, graphs, maps and other similar items are presented in a clear, legible and effective manner.
2.	Instrument for evaluating collaboration and communication skills in the form of an observation sheet.	a. Content relevance and appropriateness. b. Language. c. Method of presentation.

Source: Latisma [49] and Siburian, et al. [50].

There were more than two validators verifying the 4C assessment instrument. *Aiken* validity is used for validators ranging from 2 to 25 [51]. If the estimated validation value equals the minimal value needed in the *Aiken* table (the *Aiken* coefficient value), the product is considered to be valid. A reliability test is conducted after the validity test to assess the validator's consistency in verifying the product because there are more than two validators, the reliability test (consistency of validator evaluations) uses the *Fleiss' Kappa* test [52]. Table 7 shows the *Fleiss' Kappa* test reliability criteria.

Table 7.
Reliability criteria for the *Fleiss' Kappa* test.

Kappa score	Interpretation
$0.8 < k \leq 1$	Almost perfect agreement
$0.6 < k \leq 0.8$	Substantial agreement
$0.4 < k \leq 0.6$	Moderate agreement
$0.2 < k \leq 0.4$	Fair agreement
$0 \leq k \leq 0.2$	Slight agreement
$k < 0$	Less than a chance agreement

Source: Zuehlke, et al. [52].

The only 4C evaluation instruments that undertake empirical validity testing are questionnaires and essay questions. Direct testing was done on questionnaires and essay questions. Critical and creative thinking skills tests in the form of essays were distributed to students in class XI at Senior High School 3 and 11 Kerinci who had taken the material that was being tested. We assessed the validity and reliability values of the questionnaire items and essay questions using the SPSS application. The *Pearson Product Moment* test is used to assess validity whereas the *Cronbach's alpha* test is used to measure reliability. The validity of the question item is determined by comparing its estimated R-value with the R table. Table 8 shows reliability.

Table 8.
Reliability interpretation criteria for critical and creative skills essay questions in essay form.

Reliability coefficient	Reliability level
>0.90	Very high
0.80-0.90	High
0.70-0.79	Enough
0.60-0.69	Low
<0.60	Very low

Source: Cohen, et al. [53].

The research process begins with 1) planning (analyzing problems and development objectives). 2) Product design activities. 3) Expert validation and product testing. 4) Data analysis. 5) Conclusion. The complete research process can be depicted in Figure 1.

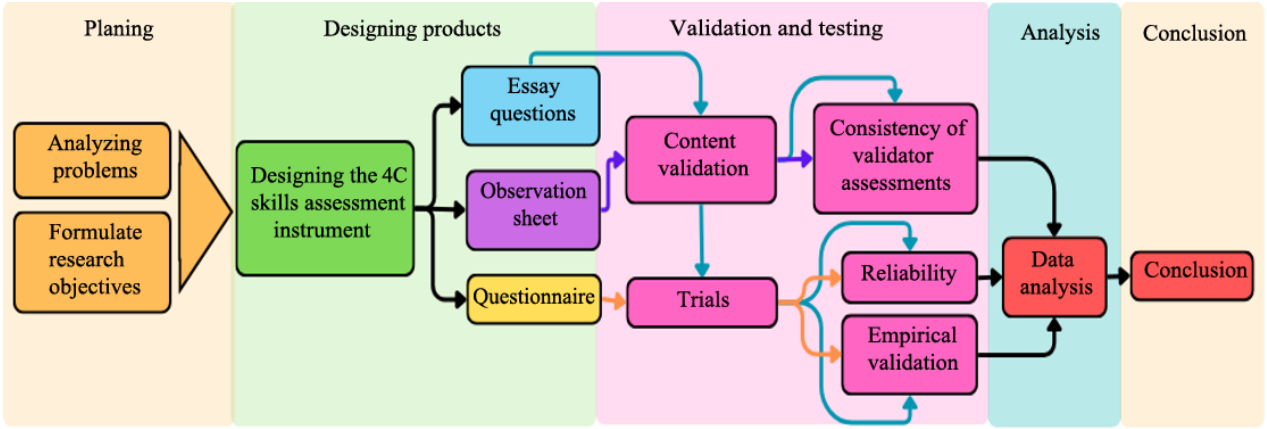


Figure 1.
Research process chart.

4. Result

4.1. Instrument for Evaluating Critical Thinking Skills

The critical thinking skills evaluation instrument developed throughout this research is a set of essay questions that measure critical thinking skills. Essay questions are accompanied by a scoring rubric based on Bloom's taxonomy as revised by Anderson and Krathwohl [30]. Two learning instrument experts and two biology education practitioner experts verified the essay questions on critical thinking skills using a validation sheet. The essay questions focused on plantae, animalia, ecosystems and environmental change. Empirical validity was tested on Senior High School 3 Kerinci class XI students. Table 9 shows the outcomes of the critical skills evaluation instrument's content and empirical validation as well as its reliability.

Table 9.
Content validation results, validator evaluation consistency, empirical validation and reliability of critical thinking skills evaluation instruments in the form of essay questions.

Form of instrument	Content validity (Category)	Validator evaluation consistency (Category)	Empirical validity (Category)	Test reliability (Category)	Number of valid items
Critical thinking skills essay questions	0.880 (Valid)*	0.280 (Fair agreement)	0.580 (Valid)**	0.897 (High)	18

Note: *Content validity: *Aiken* coefficient value = 0.870, Raters (n) = 4, and number of rating categories (c) = 5.
**Empirical validity: R table = 0.514 with n = 15.

Table 9 explains that the critical thinking skills essay questions developed are in the content valid category because the *Aiken* validity value (0.880) ≥ *Aiken* coefficient (0.870) and empirically valid because the calculated R value (0.580) > R table (0.514). The consistency of the validator assessment is in the fair agreement category (0.280) and the test reliability is in the high category (0.897).

4.2. Instrument for Evaluating Creative Thinking Skills

The instrument developed in this study for measuring creative thinking skills is a questionnaire based on Greenstein's [24] indicators. The questionnaire on creative thinking skills was also empirically validated. Empirical validity was evaluated on XI Islamic Senior High School 1, 2 and 3 Kerinci students. Table 10 shows the empirical validation and reliability outcomes of the creative skills evaluation instrument.

Table 10.
Results of empirical validation and reliability of the creative thinking skills evaluation instrument in the form of a creative thinking skills questionnaire.

Form of instrument	Empirical validity (Category)	Questionnaire reliability (Category)	Number of valid items
Creative thinking skills questionnaire	0.397 (Valid)*	0.890 (High)	46

Note: *Empirical validity: R table = 0.190 with n = 107.

According to Table 10, the questionnaire items are classified as valid (0.397) since R value (0.397) > R table (0.190) and reliability is in the high category (0.890). The total number of valid items is 46. A comprehensive list of questions related to creative thinking skills is provided in Table 11.

Table 11.
Creative thinking skills questionnaire items.

Indicators of creative thinking skills	Statement items
Curiosity	I am interested in new ideas (+).
	I feel overwhelmed by new things (-).
	I actively seek references that will help me learn (+).
	I can only accept teacher recommendations for learning resources (-).
	I actively ask questions when there is something. I don't understand (+).
	I afraid to ask questions while learning (-).
Fluency	I can explain diverse problem-solving objectives to others (+).
	I can only explain one objective for issue solutions to other people (-).
	I can provide answers based on different viewpoints (+).
	I can only provide one perspective on how to solve a problem (-).
	I can help friends view various objectives in a problem (+).
	I can focus on just one goal at a time to deal with a problem (-).
Originality	I can create something new to make products (+).
	I can only imitate existing products (-).
	I can convey new ideas clearly (+).
	It is challenging for me to convey new ideas to others (-).
	I am able to explain ideas simply and easily understood by friends (+).
	It is challenging for me to put new ideas into words (-).
Elaboration	I can improve things by adding details (+).
	I find it difficult to add detail to things (-).
	I like to add details to things (+).
	I feel burdened to provide further information (-).
	I can improve an existing product's appeal (+).
	It is difficult for me to make established things more attractive (-).
Flexibility	I am adaptable to new circumstances (+).
	I have difficulty adapting to new situations (-).
	I am capable of analyzing the problems that surround me (+).
	I can only examine problems in the textbook (-).
	I can offer a variety of solutions to daily challenges (+).
	I only believe in solutions provided by other people to overcome problems in everyday life (-).
Divergent	I can combine various ideas to get new ones (+).
	It is difficult for me to combine multiple ideas to generate new ones (-).
	I am capable of modifying existing ideas (+).
	It is difficult for me to change previous ideas (-).
	I can rearrange current ideas to generate new ones (+).
	I can only convey pre-existing ideas (-).
Messiness/Risk taking	I can experiment to generate ideas (+).
	I'm afraid of treating something since it could fail (-).
	I am inspired to try new things despite the high failure rate (+).
	I simply enjoy doing things that others have done before (-).
With others	When I collaborate or work with others, I can be more creative (+).
	I find it difficult to think freely while I am working with others (-).
	When I collaborate with others, I can produce better ideas (+).
	When I work with other people, I find it challenging to focus on developing ideas (-).
	I enjoy discussing my opinions with my friends (+).
	I feel uneasy when talking with friends (-).

Note: (+): positive statement, (-): negative statement.

This study also established essay questions based on Greenstein's [24]indicators as the instrument to assess creative thinking abilities. Two learning instrument experts and two biology education practitioners' content evaluated the creative thinking skills essay questions using a validation sheet. The essay questions focused on plantae, animalia, ecosystems, and environmental change. Empirical validity was tested on senior high school 3 and 11 Kerinci class XI students. Table 12 shows the findings of the content and empirical validation of the creative skills evaluation instrument, as well as its dependability.

Table 12.
Results of content validation, consistency of validator evaluation, empirical validation and reliability of instruments for evaluation of creative thinking skills in the form of essay questions.

Form of instrument	Content validity (Category)	Validator evaluation consistency (Category)	Empirical validity (Category)	Test reliability (Category)	Number of valid items
Creative thinking skills essay questions	0.880 (Valid)*	0.220 (Fair agreement)	0.693 (Valid)**	0.840 (High)	8

Note: *Content validity: Aiken coefficient value = 0.870, raters (n) = 4 and number of rating categories (c) = 5
**Empirical validity: R table = 0.374 with n = 28

According to Table 12, the developed creative thinking skills essay questions are content-valid since the *Aiken* validity value is 0.880 ≥ *Aiken* coefficient (0.870) and empirically valid because the computed R value (0.693) > R table (0.374). The consistency of the validator's evaluation is in the fair agreement category (0.220) and the item dependability is in the high category (0.840).

4.3. Instrument for Evaluating Collaboration Skills

The collaboration skills evaluation instrument developed in this study is a questionnaire based on indicators from Hinyard, et al. [25]. The questionnaire on collaborative skills was verified empirically. Empirical validity was evaluated on XI Islamic Senior High School) 1, 2 and 3 Kerinci students. Table 13 shows the empirical validation and reliability outcomes of the collaboration skills assessment instrument.

Table 13.
Results of empirical validation and reliability of the collaboration skills evaluation instrument in the form of the collaboration skills questionnaire.

Form of instrument	Empirical validity (Category)	Questionnaire reliability (Category)	Number of valid items
Collaboration skills questionnaire	0.527 (Valid)*	0.940 (Very high)	44

Note: *Empirical validity: R table = 0.190 with n = 107.

According to Table 13, the questionnaire items are classified as valid (0.527) since R value (0.527) > R table (0.190) and the reliability is very high (0.940). The total number of valid items is 44. Table 14 details the items of the collaborative skills questionnaire.

Table 14.
Collaboration skills questionnaire items.

Collaboration skills indicator	Statement items
Contribution	I directly convey ideas to friends.
	I express ideas to friends simply and straightforwardly.
	I logically present ideas.
	I explain ideas in the context of everyday issues.
Team support	I openly support my team.
	I discuss how to solve difficulties.
	I consider other people's perspectives.
	I believe in making collaborative decisions.
Team dynamics	I enjoy being socialized in groups.
	I engage in every group activity.
	I participate in accordance with the tasks assigned to me.
	I take on roles based on my abilities.
Interactions with others	I listen to my team members' perspectives.
	I recognize my team members' efforts.
	I appreciate group members' efforts.
	If there are any shortcomings in the group's performance, I try to improve them.
Role flexibility	I can quickly switch between duties as a leader and a member of a group, knowing that both roles are needed to achieve the work.
	I work equally when I am the group leader.
	I encourage group members to participate in decision-making.
	I don't mind switching between positions as a leader and a group member.
Motivation/ Participation	I enjoy working in groups.
	I engage in decision-making.
	I helped to improve the group's inadequacies.
	I helped to propose alternate ideas based on the outcomes of group discussions.
Quality of work	I pay attention to every detail.

Collaboration skills indicator	Statement items
	I'm excited to give the group my best effort.
	I work enthusiastically.
	I completed the task according to the assignment objectives stated at the beginning of the learning process.
Time management	I make good use of my time to ensure that everything is completed on time.
	I commit a significant amount of time to certain tasks.
	I take the time to do the work properly so that the project may be completed on time.
	I save time during class discussions.
Preparedness	I bring the references I need to do the job.
	I prepare something before work.
	I bring the assignment that the teacher assigned to me.
	I brought a textbook.
Reflection	I evaluate myself to enhance my performance in future meetings.
	I reflect on improving myself.
	I reflect to evaluate myself at the next meeting.
	I reflect to instill optimism in myself.
Team learning	I offer my perspectives on the team project even if they differ from the team's perspectives to engage the team in open discussion.
	I encourage other team members to participate in decisions that may benefit the team.
	I convey my ideas on how the team could work better together.
	I encourage others to share their opinions.

A collaboration skills observation sheet was also created as a collaborative skills evaluation instrument. Table 15 shows the outcomes of the collaboration skills evaluation instrument's content validation and reliability.

Table 15.
Results of content validation and reliability of the collaboration skills evaluation instrument in the form of the collaboration skills observation sheet.

Form of instrument	Content validity (Category)	Validator evaluation consistency (Category)
Collaboration skills observation sheet	0.900 (Valid)*	0.430 (Moderate agreement)

Note: *Content validity: Aiken coefficient value = 0.870, raters (n) = 4 and number of rating categories (c) = 5.

According to Table 15, the collaboration skills observation sheet has been classified as valid in content due to the *Aiken* validity score (0.900) ≥ *Aiken* coefficient (0.870) and the consistency of the validator's evaluation being in the moderate agreement category (0.430). The observation sheet is equipped with an assessment rubric modified from Hinyard, et al. [25].

4.4. Instruments for Evaluating Communication Skills

The communication skills evaluation instrument developed throughout this research is a questionnaire based on Rubin and Martin's [26] indicators. The questionnaire on communication skills was empirically validated. Empirical validity was evaluated on XI Islamic Senior High School 1, 2 and 3 Kerinci students. Table 16 shows the findings of the empirical validation of the communication skills evaluation instrument as well as its dependability.

Table 16.
Results of empirical validation and reliability of the communication skills evaluation instrument in the form of a communication skills questionnaire.

Form of Instrument	Empirical validity (Category)	Questionnaire reliability (Category)	Number of valid items
Communication skills questionnaire	0.500 (Valid)*	0.930 (Very high)	40

Note: *Empirical validity: R table = 0.190 with n = 107.

According to Table 16, the questionnaire items are classified as valid (0.500) since R value (0.500) > R table (0.190) and the reliability is in the very high category (0.930). The total number of eligible items is 44. Table 17 details the items of the collaborative skills questionnaire.

Table 17.
Communication skills questionnaire items.

Communication skills instrument	Statement items
Self-disclosure	I revealed my true self to my friends.
	I respond positively to other people's opinions.
	I openly communicate my ideas.
	I am open to hearing other people's perspectives.
Empathy	I am sensitive to or attentive to other people's problems.
	I offer opportunities to friends who are less involved in the group.
	I accept criticism or input from others.
	I portray myself as someone who is equal to or has the same role and rights as everyone else in the group.
Social relaxation	I am at ease in small group meetings.
	I enjoy sharing information with friends.
	I am flexible in making decisions.
	I feel confident in expressing my ideas, views etc.
Assertiveness	I present logical arguments.
	I am willing to reject other people's arguments for logical reasons.
	I do not make decisions unilaterally.
	I use language that does not harm others.
Altercentrism	I let others know that I understand what they are saying.
	I listen to friends who express their points of view.
	I ask and answer questions during the discussion.
	I give suggestions for group discussions.
Interaction Management	I lead the conversation in which I am participating by negotiating the subjects that need to be discussed.
	I clearly explain the material or my opinions.
	I restrict the discussion if the topic deviates from the content.
	I organize and manage each activity in detail.
Expressiveness	I express myself well verbally.
	I emphasize physical movements, voice or facial expressions in proportion to their use and context.
	I avoid using negative emotions with other people.
	I avoid displaying anger or rage.
Supportiveness	I communicate by describing something.
	I interact in a polite manner.
	I discuss topics in neutral words or do not discuss sensitive or private subjects.
	I communicate without encroaching on the person I'm speaking with or being evaluative.
Immediacy	I am a good listener.
	I am engaged in sharing information.
	I interact casually.
	I care about my friends.
Environmental Control	I met my communication objectives.
	I persuade others that my position in the group is necessary.
	I communicate to exchange ideas.
	I value the work of each group member and do not undervalue their performance.

A collaboration skills evaluation sheet was also created as an instrument to evaluate communication skills. Table 18 shows the outcomes of the communication skills evaluation instrument's content validity and reliability.

Table 18.
Results of content validation and reliability of the communication skills evaluation instrument in the form of a communication skills observation sheet.

Form of instrument	Content validity (Category)	Validator evaluation consistency (Category)
Communication skills observation sheet	0.900 (Valid)*	0.430 (Moderate agreement)

Note: *Content validity: Aiken coefficient value = 0.870, raters (n) = 4 and number of rating categories (c) = 5

According to Table 18, the communication skills observation sheet has been classified as content valid due to the *Aiken* value (0.900) ≥ *Aiken* coefficient (0.870) and the consistency of the validator's evaluation being in the moderate

agreement category (0.430). The observation sheet is equipped with an assessment rubric modified from Rubin and Martin [26].

5. Discussion

5.1. Instrument for Evaluating Critical Thinking Skills

Critical thinking skills instruments in the form of essay questions were developed based on the research findings. An 18-item critical thinking skills instrument in the form of essay questions on plantae, animalia, ecosystems and environmental change was developed with an average content validity of 0.880 (valid), validator assessment consistency of 0.280 (fair agreement), empirical validity of 0.580 (valid) and test reliability of 0.897 (high).

Essay questions can be used more effectively to measure certain complex learning outcomes such as organization, synthesis and analysis [54]. The benefits of using essay questions are: 1) They can be used to evaluate higher-order or critical thinking skills. 2) Evaluate students' thinking and reasoning. 3) Provide authentic experiences [55]. The question items take the form of an open question. Open questions encourage students to participate in more cognitive tasks than closed questions [56].

The form of critical thinking skills essay questions comprises three components: problems (in article form), questions and an assessment rubric (see Figure 2). The purpose of cases or problems presented in the form of articles on questions is to stimulate students' thinking processes. Students who are unfamiliar with critical thinking can be trained by being presented them with contentious situations [5]. Contentious subjects relate to problems in students' daily lives.

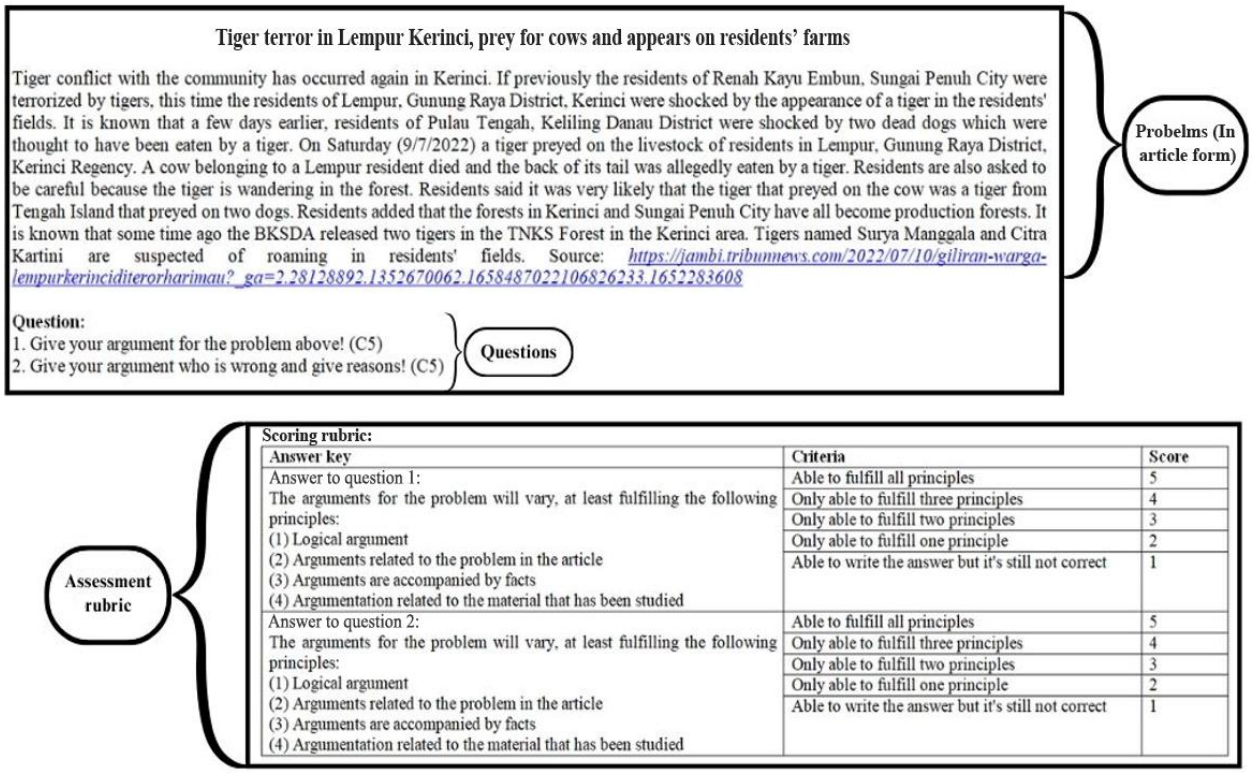


Figure 2.
Critical thinking skills essay question components.

Evaluations and other higher-level thinking generally involve stimuli in the form of cases. Stimuli can encourage students to relate their knowledge to current real-world problem scenarios such as information technology, science, economics, health, education, character and infrastructure [57]. The stimuli or situations raised in the critical thinking skills essay questions involve cases that exist in the students' surroundings namely difficulties in Kerinci Regency, Indonesia.

Metacognition is one of the supporting elements that make up critical thinking skills [58]. Metacognition involves analytical activities. The types of questions that can be asked to enhance analytical skills (C4) can be done by 1) looking for the primary idea in the paragraph but not overtly stating it in the text as a whole. 2) Analyzing arguments or conclusions [57]. Questions that might be presented to improve students' analytical skills include: 1) Explain your reasoning for making the claim. 2) What are the pros and cons of the arguments regarding the reading? 3) What assumptions must we make to accept the conclusion? 4) What is your justification for saying that? [59].

In addition, there are numerous sorts of questions that may be used to evaluate students' capacity to evaluate skills (C5), such as 1) determining the reliability of a source of information. 2) Identifying assumptions implicit in the information and 3) identifying rhetorical and persuasive methods [57]. Examples of questions that can be asked to hone students' evaluation skills include 1) How credible is the claim? 2) Why do you think this person's claims are credible? 3) How strong are the arguments? 4) Are the facts that we have correct? 5) How confident are we in our conclusions, given what we know now? [59].

Furthermore, in the Revised Bloom's Taxonomy, creating (C6) is defined as the action of putting pieces together to make a cohesive or functional whole rearranging elements into a new pattern or structure [30]. Questions at the creative level need the

capacity to address problems by devising solutions, planning, developing procedures to reach certain objectives or producing something new [57].

5.2. Instrument for Evaluating Creative Thinking Skills

Instruments for creative thinking skills in the form of questionnaires and essay questions were developed based on the research findings. There are 46 valid creative thinking skills questionnaire items with an empirical validity of 0.397 (valid) and a reliability of 0.890 (high). The average content validity of essay questions is 0.880 (valid), validator evaluation consistency is 0.220 (fair agreement), empirical validity is 0.693 (valid) and test reliability is 0.840 (high). According to Greenstein [24], creative thinking skills indicators were used to design the questionnaire and essay questions as well as the rubric for assessing creative thinking skills. Greenstein's [24] indicators of creative thinking skills include curiosity, fluency, originality, elaboration, flexibility, divergence, messiness and risk-taking among others.

Creative thinking can lead to behaviours or activities that show a student is applying their creative thinking skills. Questionnaires are useful for assessing knowledge, attitudes, beliefs, intentions, cognition, emotions and behavior [60]. The evaluation instrument for creative thinking skills was created in the form of a creative thinking skills questionnaire. This study's creative thinking skills questionnaire is divided into four components: filling out instructions, statement items, identity and answer sheet (see Figure 3). A questionnaire is a set of formal questions designed to elicit information from respondents [61]. Questionnaires are used in a variety of circumstances to gather information about individuals' opinions and behaviors. When creating a questionnaire, the more intricate a statement, the less likely it will be answered by the respondent [62].

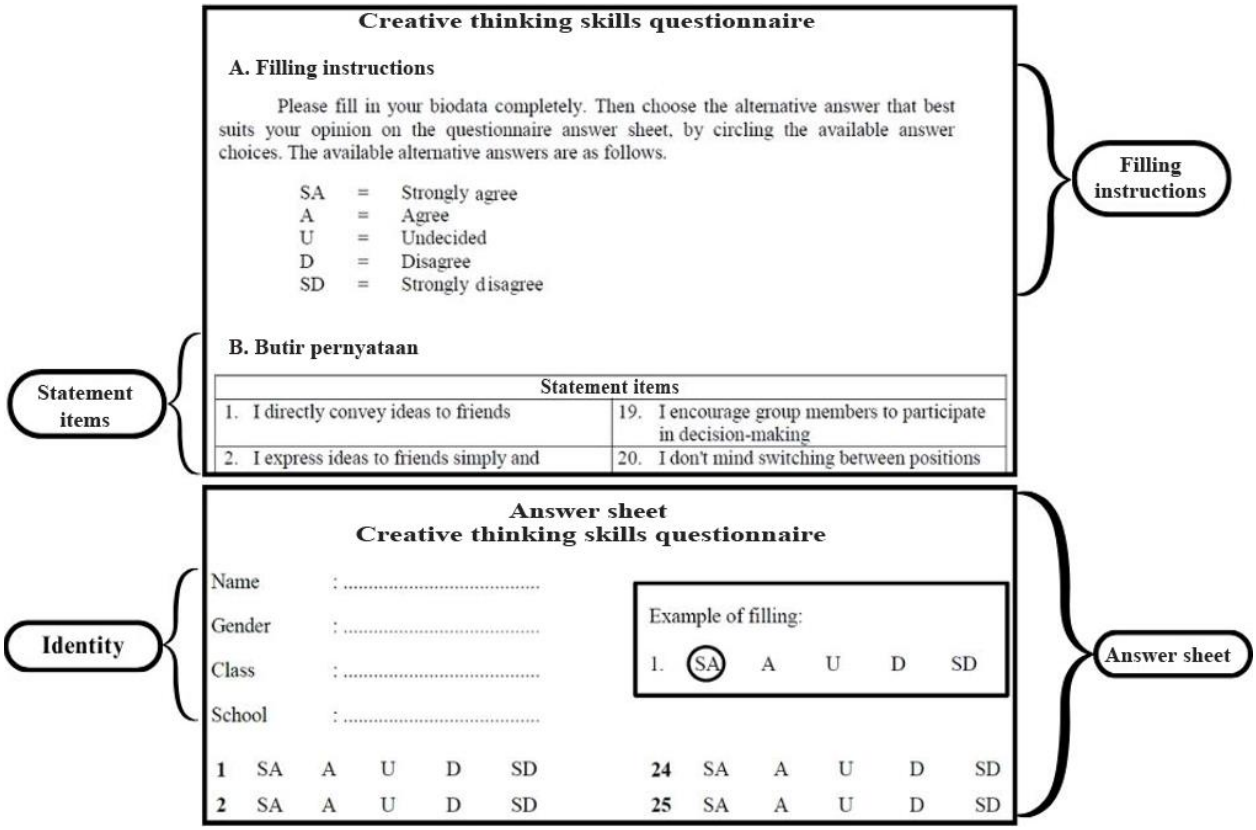


Figure 3.
Creative thinking skills questionnaire component.

A creative thinking skills questionnaire is used to measure creative thinking skills and students only pick or tick responses that represent their circumstances. The responses are written on a Likert scale 5. A closed statement form was used to create the creative thinking skills questionnaire. Closed statements were chosen because they save time [27]. If assessments take too long, teachers' time in the classroom is restricted. The number of questionnaire items can be decided by the teacher based on the amount of time necessary for evaluation. It is essential to highlight that the items chosen must represent each indicator of creative thinking skills.

Creative thinking instruments were also developed in the form of essay questions. Creative thinking skills essay questions also include four components: problems (in the form of articles), questions, answer columns to lead students to think systematically, and an assessment rubric (see Figure 4). The issues stated in the question are issues that students face in Kerinci Regency, Indonesia. The issues presented are intended to provoke students to think about and provide solutions to the issues. Creative thinking is described as the metacognitive process of establishing new associations that are beneficial for improved problem-solving, plan generation or the production of clear patterns, structures or goods [35]. Creativity is the synthesis or expansion of existing knowledge and skills [15].

Diversity of community medicinal plants in the Talang Rencong forest, Pulam Sangkar village, Kerinci regency, Jambi

Indonesia has around 30,000 types of medicinal plants. Based on the richness of this flora, Indonesia certainly has the potential to develop herbal products whose quality is equivalent to modern medicine. Modern medicine in Indonesian society cannot yet be reached by all levels of society, only around 25% have reached it and the rest have not been reached. The role of traditional medicine recipes is very helpful, especially for people who live in remote areas with minimal access. The research was carried out in April-May 2019 in the Talang Rencong Traditional Forest, Pulau Sangkar Village, Kerinci Regency, Jambi. The research area taken was 1 Ha or 5% of the total area.

The research results found that the family that is widely used by the public is the Asteraceae family with six types, followed by the Euphorbiaceae family with four types. According to smart people/shamans in Pulau Sangkar Village, this plant from the Asteraceae family has many benefits, such as *Ageratum conyzoides* (L.) (Figure 1) which is usually used to treat bloating, but can also be used to treat wounds. Source: *Adriadi, A., Nursanti, N., & Puspitasari, R. (2020). Keanekaragaman Tumbuhan Obat Masyarakat di Hutan Talang Rencong Desa Pulau Sangkar, Kabupaten Kerinci, Jambi. Media Konservasi, 25(2), 134-139.*

Gambar 1. *Ageratum conyzoides* (L.)

Probelms (In article form)

Question:

1. Based on Article: a) explain the interesting idea of the article, about the plant *Ageratum conyzoides* (L.)!; b) connect interesting ideas with the material that has been studied!; c) criticize an interesting idea by asking several questions; d) try to answer these critical questions with answers that are relevant to the material! (Curiosity).

Questions

Answer:

a) Interesting ideas in the article	b) The relationship between the ideas found and the material	c) Criticize ideas (ask questions related to the ideas proposed)	d) Relevant answers to the questions asked

Answer columns

Creative thinking skills assessment rubric:

Indicators	Descriptor	Criteria	Scoring indicators	Score
Curiosity	Interest in specific aspects or materials, new ideas, and an active search for new concepts.	1. Students are interested in new elements or materials 2. Students connect ideas with material 3. Students ask about ideas or material 4. Students actively look for new ideas	Students are able to meet all criteria	5
			Students are only able to fulfill 3 criteria	4
			Students are only able to fulfill 2 criteria	3
			Students are only able to fulfill 1 criterion	2
			The student has tried to answer, but the answer is still not correct	1

Assessment rubric

Figure 4.
Creative thinking skills essay question components.

Students may have the innate ability to be creative but not have the resources or opportunity to express it freely [63]. It is hoped that the instrument developed will be able to motivate and become a reference for teachers especially high school teachers in Kerinci Regency to carry out learning oriented towards creative thinking skills.

5.3. Instrument for Evaluating Collaboration Skills

Collaboration instruments were developed in the form of questionnaires and observation sheets based on the findings of the research. There are 44 valid collaboration skills questionnaire items with an empirical validity of 0.527 (valid) and a reliability of 0.940 (very high). The collaboration skills observation sheet has also been classified as valid in content (0.900) and consistent in the validity assessor's evaluation of 0.430 (moderate agreement). Hinyard, et al.'s [25] collaboration skills indicators were used to create collaboration skills questionnaires and observation sheets. Collaboration skills indicators from Hinyard, et al. [25] include contribution, team support, team dynamics, interactions with others, role flexibility, motivation and participation, quality of work, time management, preparedness, reflection and team learning.

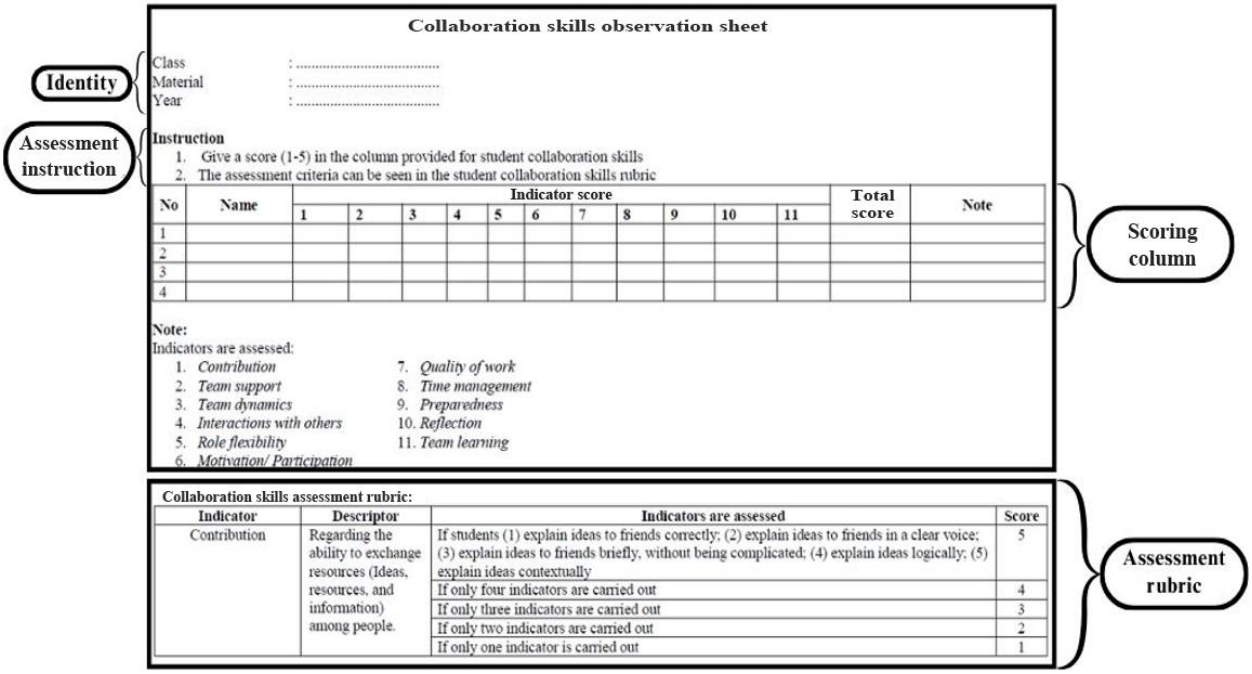
The collaboration skills assessment instrument in this research was developed in the form of a collaboration skills questionnaire. Questionnaires are a tool that can be used for intervention and improvement [64]. The questionnaire developed in this research was used to assess behavior in terms of student collaboration skills. The skills instrument in the form of a collaboration skills questionnaire consists of four components: filling out instructions, statement items, identity and answer sheet.

The statements in the questionnaire are in closed form. Closed statements restrict respondents' responses to a defined set of options [65]. Using closed statements has the benefit of being easier to code, verify and complete [62]. This satisfies the evaluation process's requirements for time efficiency. The cooperation skills questionnaire uses a 5-Likert scale for response options. The Likert scale has various advantages including the following: 1) It is easy for researchers to create and use. 2) It is easy for respondents to understand [61]. The linguistic component must be taken into account while creating a questionnaire. The questionnaire's language must be acceptable for the student's level of comprehension. It is critical to organize questions in a way that participants can comprehend and that is acceptable for their educational and cultural levels [27].

An observation sheet was also designed as an instrument for measuring collaboration skills. Observation sheets are primarily intended for field observations and tabulation phases where they provide direction for correctly recording information and ease coding, data entry and analysis in the field [61]. There are two types of observations that teachers could carry out in the classroom namely: 1) intentional observations occur throughout continuous teaching and learning activities as well as interactions between teachers and students. In other words, unforeseen chances happen when the teacher considers a certain aspect of individual student learning in the context of classroom activities. 2) Planned observation which is the purposeful preparation of chances for teachers to observe certain learning outcomes. These planned opportunities might occur as part of regular classroom activities or through the setting of evaluation tasks (such as practical exercises or performances) [66].

The observation sheet for student collaboration skills is composed of four components: identity, assessment instructions,

assessment sheet and assessment rubric (see Figure 5). The assessment rubric was created using Hinyard, et al.'s [25] indicators. Teacher observations are useless without planning [66]. It is critical to examine the quantity of items in the observation instrument in relation to the observer's duration and concentration [67]. If the teacher is unable to observe individual performance, it is strongly advised that observations be conducted in groups.



Collaboration skills observation sheet

Class : .....
Material : .....
Year : .....

Instruction
1. Give a score (1-5) in the column provided for student collaboration skills
2. The assessment criteria can be seen in the student collaboration skills rubric

No	Name	Indicator score											Total score	Note
		1	2	3	4	5	6	7	8	9	10	11		
1														
2														
3														
4														

Note:
Indicators are assessed:
1. *Contribution*
2. *Team support*
3. *Team dynamics*
4. *Interactions with others*
5. *Role flexibility*
6. *Motivation/ Participation*
7. *Quality of work*
8. *Time management*
9. *Preparedness*
10. *Reflection*
11. *Team learning*

Collaboration skills assessment rubric:

Indicator	Descriptor	Indicators are assessed	Score
Contribution	Regarding the ability to exchange resources (Ideas, resources, and information) among people.	If students (1) explain ideas to friends correctly; (2) explain ideas to friends in a clear voice; (3) explain ideas to friends briefly, without being complicated; (4) explain ideas logically; (5) explain ideas contextually	5
		If only four indicators are carried out	4
		If only three indicators are carried out	3
		If only two indicators are carried out	2
		If only one indicator is carried out	1

Figure 5.
Collaboration skills observation sheet component.

5.4. Instrument for Evaluating Communication Skills

Communication skills instruments such as questionnaires and observation sheets were developed based on the research findings. There are 40 valid communication skills questionnaire items with an average empirical validity of 0.500 (valid) and questionnaire reliability of 0.930 (very high). The produced communication skills observation sheet was also evaluated as valid in terms of content (0.900) and consistency of the validator's evaluation of 0.430 (moderate agreement). Rubin and Martin's [26] communication skills indicators were used to create communication skills questionnaires and observation sheets. Rubin and Martin's [26] communication skills indicators include self-disclosure, empathy, social relaxation, assertiveness, alternation, interaction management, expressiveness, supportiveness, immediacy and environmental mental control.

Communication activities are often carried out verbally because every lesson must include communication activities. Oral communication skills might be considered the "heart" of learning. Oral communication's role in learning includes: 1) instructive activity that necessitates oral communication to transmit knowledge and 2) the heuristic function that needs verbal contact to learn by asking questions or seeking answers [48].

The communication skills instrument in this research was developed in the form of a questionnaire. Questionnaires are the primary means of gathering information from respondents [27]. Questionnaires enable the collection of quantitative data in a standardized manner resulting in standardized data that is internally consistent and coherent for analysis [61]. In this instance, the data is on the students' communication skills and ability scores. A Likert scale is used in the communication skills questionnaire. Subjects are asked to rate how much they agree or disagree with a statement using a Likert scale [62]. The communication skills questionnaire can be answered on a 5-point scale.

A communication skills observation sheet was also created as a communication skills evaluation instrument. The most appropriate approach for analyzing the application of authentic evaluation is believed to be observation [68]. The ability of teacher observation to promote assessment validity is a compelling reason to use it in assessment [66]. The observation sheet for student communication skills is composed of four sections: identity, assessment instructions, scoring column and assessment rubric as they were on the prior collaboration skills observation sheet.

6. Conclusion

The conclusion of this research and development are as follows: 1) an instrument for evaluating critical thinking skills in the form of valid and reliable essay questions. 2) Instruments for testing creative thinking skills such as valid and reliable questionnaires and essay questions. 3) Instruments for evaluating collaboration skills such as valid and reliable questionnaires and observation sheets. 4) Instruments for evaluating communication skills such as valid and reliable questionnaires and observation sheets.

7. Implications and Limitations

The implications of this research are that the 4C skills evaluation instrument that has been developed may be used in biology learning by Indonesian high school biology teachers particularly biology teachers at high schools throughout Kerinci Regency. This 4C skills research instrument has been tailored to the abilities of high school students as well as to local culture, particularly Kerinci Regency. This 4C skills instrument is intended to assist instructors in developing and empowering 4C skills in the classroom.

Limitations of this research: The essay questions on critical and creative thinking skills are still confined to plantae, animalia, ecosystems and environmental change. Future studies will hopefully be able to broaden the scope of this 4C skills instrument particularly in terms of materials, evaluation forms and research samples.

References

[1] K. Akyeampong, "Reconceptualised life skills in secondary education in the African context: Lessons learnt from reforms in Ghana," *International Review of Education*, vol. 60, no. 2, pp. 217-234, 2014.

[2] T. Stanley, *Creating life-long learners : Using project- based management to teach 21st century skills*. Thousand Oaks: Corwin, 2016.

[3] N. P. A. H. Sanjayanti, I. W. Suastra, K. Suma, and P. B. Adnyana, "Effectiveness of science learning model containing balinese local wisdom in improving character and science literacy of junior high school students," *International Journal of Innovative Research and Scientific Studies*, vol. 5, no. 4, pp. 332-342, 2022. https://doi.org/10.53894/ijirss.v5i4.750

[4] E. Ariyati, H. Susilo, H. Suwono, and F. Rohman, "Empowering critical thinking skills through process oriented guided inquiry learning (POGIL)," *Scholaria: Jurnal Pendidikan Dan Kebudayaan*, vol. 11, no. 3, pp. 208-215, 2021.

[5] R. M. Felder and R. Brent, *Teaching and learning STEM: A practical guide*. San. Francisco: Jossey-Bass, 2016.

[6] Department for Education and Skills UK, *Pedagogy and practice: Teaching and learning in secondary schools*. United Kingdom: Crown, 2004.

[7] A. Crawford, W. Saul, S. R. Mathews, and J. Makinster, *Teaching and learning strategies for the thinking classroom*. New York: The International Debate Education Association, 2005.

[8] C. Reynolds, D. D. Stevens, and E. West, "“I’m in a professional school! Why are you making me do this?” A cross-disciplinary study of the use of creative classroom projects on student learning," *College Teaching*, vol. 61, no. 2, pp. 51-59, 2013. https://doi.org/10.1080/87567555.2012.731660

[9] M. D. Mumford, K. E. Medeiros, and P. J. Partlow, "Creative thinking: Processes, strategies, and knowledge," *The Journal of Creative Behavior*, vol. 46, no. 1, pp. 30-47, 2012. https://doi.org/10.4337/9780857939814.00029

[10] S. M. Wechsler *et al.*, "Creative and critical thinking: Independent or overlapping components?," *Thinking Skills and Creativity*, vol. 27, pp. 114-122, 2018. https://doi.org/10.1016/j.tsc.2017.12.003

[11] T. Nikkola, J. Reunamo, and I. Ruokonen, "Children’s creative thinking abilities and social orientations in Finnish early childhood education and care," *Early Child Development and Care*, vol. 192, no. 6, pp. 872-886, 2022. https://doi.org/10.1080/03004430.2020.1813122

[12] S. M. Ritter and N. Mostert, "Enhancement of creative thinking skills using a cognitive-based creativity training," *Journal of Cognitive Enhancement*, vol. 1, pp. 243-253, 2017. https://doi.org/10.1007/s41465-016-0002-3

[13] D. Raviqah, F. Rohman, and S. R. Lestari, "Developing of electronic module on problem-based learning (Pbl) to improve creative thinking skills," *Bioedukasi*, vol. 21, no. 2, pp. 111-116, 2023. https://doi.org/10.19184/bioedu.v21i2.39620

[14] M. Sun, M. Wang, and R. Wegerif, "Effects of divergent thinking training on students’ scientific creativity: The impact of individual creative potential and domain knowledge," *Thinking Skills and Creativity*, vol. 37, p. 100682, 2020. https://doi.org/10.1016/j.tsc.2020.100682

[15] K. H. Kim, "Demystifying creativity: What creativity isn’t and is?," *Roeper Review*, vol. 41, no. 2, pp. 119-128, 2019. https://doi.org/10.1080/02783193.2019.1585397

[16] R. Cole *et al.*, "One-on-one and small group conversations with an intelligent virtual science tutor," *Computer Speech & Language*, vol. 50, pp. 157-174, 2018. https://doi.org/10.1016/j.csl.2018.01.002

[17] S. Ilma, M. H. I. Al-Muhdhar, F. Rohman, and M. Saptasari, "Students collaboration skills in science learning," in *Proceedings of the 2nd International Conference on Innovation in Education and Pedagogy (ICIEP 2020)*, 2022, vol. 619, pp. 204–208, doi: https://doi.org/10.2991/assehr.k.211219.037.

[18] A. Al Ansari, A. W. Agab, S. D. Al Sayed, and N. J. Al Fudhala, "Multisource feedback tool for the assessment of medical student clerks in professionalism, communication, and collaboration skills," *Medical Science Educator*, vol. 26, pp. 609-616, 2016. https://doi.org/10.1007/s40670-016-0311-2

[19] S. V. Bestelmeyer, M. M. Elser, K. V. Spellman, E. B. Sparrow, S. S. Haan-Amato, and A. Keener, "Collaboration, interdisciplinary thinking, and communication: New approaches to K–12 ecology education," *Frontiers in Ecology and the Environment*, vol. 13, no. 1, pp. 37-43, 2015. https://doi.org/10.1890/140130

[20] M. Slota, M. McLaughlin, L. Bradford, J. F. Langley, and S. Vittone, "Visual intelligence education as an innovative interdisciplinary approach for advancing communication and collaboration skills in nursing practice," *Journal of Professional Nursing*, vol. 34, no. 5, pp. 357-363, 2018. https://doi.org/10.1016/j.profnurs.2017.12.007

[21] T. G. Spies and Y. Xu, "Scaffolded academic conversations: Access to 21st-Century collaboration and communication skills," *Intervention in School and Clinic*, vol. 54, no. 1, pp. 22-30, 2018. https://doi.org/10.1177/1053451218762478

[22] A. Amrianto, F. Rohman, A. Dharmawan, and M. S. Sari, "The relationship between creative thinking , collaboration , and communication skills in high school level biology learning," *Specialusis Ugdymas*, vol. 1, no. 44, pp. 299-310, 2023.

[23] H. Ozkan, M. Dalli, E. Bingol, S. C. Metin, and D. Yarali, "Examining the relationship between the communication skills and self-efficacy levels of physical education teacher candidates," *Procedia-Social and Behavioral Sciences*, vol. 152, pp. 440-445, 2014. https://doi.org/10.1016/j.sbspro.2014.09.228

[24] L. M. Greenstein, *Assessing 21st century skills: A guide to evaluating mastery and authentic learning*. California: Corwin Press, 2012.

[25] L. Hinyard, E. Toomey, K. Eliot, and A. Breitbach, "Student perceptions of collaboration skills in an interprofessional context: Development and initial validation of the self-assessed collaboration skills instrument," *Evaluation & the Health Professions*, vol. 42, no. 4, pp. 450-472, 2019. https://doi.org/10.1177/0163278717752438
[26] R. B. Rubin and M. M. Martin, "Development of a measure of interpersonal communication competence," *Communication Research Reports*, vol. 11, no. 1, pp. 33-44, 1994. https://doi.org/10.1080/08824099409359938
[27] A. M. Kazi and W. Khalid, "Questionnaire designing and validation," *Journal of the Pakistan Medical Association*, vol. 62, no. 5, pp. 514-516, 2012. https://doi.org/10.1016/j.sapharm.2007.10.007
[28] A. Yusrina and L. Bima, *Classroom observation tool for assessing the dimensions of teaching practices (CERDAS)*. Indonesia: The SMERU Research Institute, 2020.
[29] K. Seifert and R. Sutton, *Educational psychology*. Switzerland: Jacobs Foundation, 2009.
[30] L. W. Anderson and D. R. Krathwohl, *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Logman, 2001.
[31] M. A. Hariyanto, S. Mahanal, and F. Rohman, "Analyzing the contribution of critical thinking skills and social skills on students' character by applying discovery learning models," *International Journal of Education and Practice*, vol. 10, no. 1, pp. 42–53, 2022. https://doi.org/10.18488/61.v10i1.2907
[32] A. Muhlisin, H. Susilo, M. Amin, and F. Rohman, "Improving critical thinking skills of college students through RMS model for learning basic concepts in science," *Asia-Pacific Forum on Science Learning and Teaching*, vol. 17, no. 1, pp. 1-24, 2016.
[33] N. Nuraini, "Critical thinking profile of students of biological teacher candidate as efforts to prepare 21st century generation," *Jurnal Penelitian Pendidikan Biologi*, vol. 1, no. 2, pp. 89-96, 2017.
[34] H. Rahmatika, S. R. Lestari, and M. S. Sari, "A pbl-based circulatory system e-module based on research results to improve students' critical thinking skills and cognitive learning outcome," *Jurnal Pendidikan Indonesia*, vol. 9, no. 4, pp. 565-575, 2020. https://doi.org/10.23887/jpi-undiksha.v9i4.25647
[35] R. A. Hargrove, "Assessing the long-term impact of a metacognitive approach to creative skill development," *International Journal of Technology and Design Education*, vol. 23, pp. 489-517, 2013. https://doi.org/10.1007/s10798-011-9200-6
[36] K. L. Lai and P. Hunt, "Creative dance: Singapore children's creative thinking and problem-solving responses," *Research in Dance Education*, vol. 7, no. 1, pp. 35-65, 2006. https://doi.org/10.1080/14617890600610661
[37] G. Rodríguez, J. Díez, N. Pérez, J.-E. Baños, and M. Carrió, "Flipped classroom: Fostering creative skills in undergraduate students of health sciences," *Thinking Skills and Creativity*, vol. 33, p. 100575, 2019. https://doi.org/10.1016/j.tsc.2019.100575
[38] T. Tang, V. Vezzani, and V. Eriksson, "Developing critical thinking, collective creativity skills and problem solving through playful design jams," *Thinking Skills and Creativity*, vol. 37, p. 100696, 2020. https://doi.org/10.1016/j.tsc.2020.100696
[39] I. Iwan, S. B. Sumitro, I. Ibrohim, and F. Rohman, "Analysis of critical thinking skills for biology teacher prospective at University of Papua," *Jurnal Eduscience*, vol. 10, no. 2, pp. 442-450, 2023. https://doi.org/10.36987/jes.v10i2.4516
[40] N. Syamsiara, S. Zubaidah, S. Mahanal, and F. Rohman, "ERCoRe learning model to improve creative-thinking skills of preservice biology teachers," *Journal for the Education of Gifted Young Scientists*, vol. 8, no. 1, pp. 549-569, 2020. https://doi.org/10.17478/jegys.673022
[41] S. P. Putri, B. Hariyadi, and E. Anggereini, "Development of essay items based on critical thinking in biology subject material on environmental change at the high school level in Sungai Bahar, Muaro Jambi Regency," *BIODIK: Jurnal Ilmiah Pendidikan Biologi*, vol. 9, no. 2, pp. 143–151, 2023. https://doi.org/10.22437/bio.v9i2.22412
[42] D. D. Bricker, H. S. Felimban, F. Y. Lin, S. M. Stegenga, and S. O. M. Storie, "A proposed framework for enhancing collaboration in early intervention/early childhood special education," *Topics in Early Childhood Special Education*, vol. 41, no. 4, pp. 240-252, 2022. https://doi.org/10.1177/0271121419890683
[43] P. Resta and H. Lee, *Peer and self-assessment. In Virtual Teamwork: Mastering the Art and Practice of Online Learning and Corporate Collaboration*. John Wiley & Sons, Inc. https://doi.org/10.1002/9780470615782.ch3, 2010.
[44] W. Agustin, M. S. Sari, Suhadi, and S. Juwariyah, "Developing a biology E-module based on Pjbl-steam model to improve students ' collaboration skills," *Bioedukasi*, vol. 21, no. 2, pp. 117–127, 2023. https://doi.org/10.19184/bioedu.v21i2.39621
[45] S. Ilma, M. H. I. Al-Muhdhar, F. Rohman, and M. S. Sari, "Promote collaboration skills during the COVID-19 pandemic through predict-observe-explain-based project (POEP) learning," *Jurnal Pendidikan Biologi Indonesia*, vol. 8, no. 1, pp. 32–39, 2022. https://doi.org/10.22219/jpbi.v8i1.17622
[46] S. Richards, G. Ruch, and P. Trevithick, "Communication skills training for practice: The ethical dilemma for social work education," *Social Work Education*, vol. 24, no. 4, pp. 409-422, 2005. https://doi.org/10.1080/02615470500096928
[47] J. Brownell, *The skills of listening-centered communication. In Andrew D. Wolvin (Ed.), Listening and human communication in the 21st century*. Oxford, UK: Wiley-Blackwell, 2010.
[48] S. R. Hikamah, F. Rohman, and N. Kurniawan, "Developing virtual communication skills in online learning based on modified PBL during the covid-19 pandemic," *International Journal of Education and Practice*, vol. 9, no. 2, pp. 323-339, 2021. https://doi.org/10.18488/journal.61.2021.92.323.339
[49] Latisma, *Educational evaluation*. Padang: UNP Press, 2011.
[50] J. Siburian, A. D. Corebima, Ibrohim, and M. Saptasari, "The analysis validity of environmental science development of learning devices inquiry strategy and instruments test critical thinking, creative thinking and student cognitive learning outcomes," *Biodik: Jurnal Ilmiah Pendidikan Biologi*, vol. 5, no. 1, pp. 31–47, 2019. https://doi.org/10.22437/bio.v5i1.6825
[51] L. R. Aiken, "Three coefficients for analyzing the reliability and validity of ratings," *Educational and Psychological Measurement*, vol. 45, no. 1, pp. 131-142, 1985. https://doi.org/10.1177/0013164485451012
[52] D. Zuehlke, T. Geweniger, U. Heimann, and T. Villmann, "Fuzzy fleiss-kappa for comparison of fuzzy classifiers," in *ESANN'2009 Proceedings, European Symposium on Artificial Neural Networks, 2009*, 2009.
[53] L. Cohen, L. Manion, and K. Morrison, *Research methods in education*. New York: Routledge, 2018.
[54] M. A. Khan and U. Ishfaq, "Test-score reliability of essay questions in BA examination," *Global Language Review*, vol. 1, pp. 58-65, 2016. https://doi.org/10.31703/glr.2016(i-i).05
[55] C. M. Reiner, T. W. Bothell, R. R. Sudweeks, and B. Wood, *How to prepare effective essay questions: Guidelines for university faculty*. Amerika Serikat: Department of Instructional Psychology and Technology, 2002.

[56] R. Sommer and B. A. Sommer, "The dreaded essay exam," *Teaching of Psychology,* vol. 36, no. 3, pp. 197-199, 2009. https://doi.org/10.1080/00986280902959820

[57] I. W. Widana, "Higher order thinking skills assessment (HOTS)," *Jaurnal of Indonesian Student Assessment and Evaluation,* vol. 3, no. 1, pp. 32–44, 2017. https://doi.org/10.21009/jisae.v3i1.4859

[58] M. N. I. Buku, A. D. Corebima, and F. Rohman, "The correlation between metacognitive skills and the critical thinking skills of the senior high school students in biology learning through the implementation of problem based learning (PBL) in Malang, Indonesia," *International Journal of Academic Research and Development,* vol. 1, no. 5, pp. 58-63, 2016.

[59] P. A. Facione, "Critical thinking: What it is and why it counts," *Insight Assessment,* vol. 1, no. 1, pp. 1-23, 2011.

[60] J. Rattray and M. C. Jones, "Essential elements of questionnaire design and development," *Journal of Clinical Nursing,* vol. 16, no. 2, pp. 234-243, 2007. https://doi.org/10.1111/j.1365-2702.2006.01573.x

[61] N. K. Malhotra, *Chapter 5 questionnaire design and scale development. In the Handbook of Marketing Research: Uses, Misuses, and Future Advances*. London: Sage Publications, 2006.

[62] A. Williams, "How to… write and analyse a questionnaire," *Journal of Orthodontics,* vol. 30, no. 3, pp. 245-252, 2003. https://doi.org/10.1093/ortho/30.3.245

[63] V. Sandhiya and M. Bhuvaneswari, "Influence of psychological variables on divergent thinking in adolescents: A cross-sectional study," *International Journal of Innovative Research and Scientific Studies,* vol. 6, no. 4, pp. 1006-1014, 2023. https://doi.org/10.53894/ijirss.v6i4.2218

[64] T. S. Kristensen, "A questionnaire is more than a questionnaire," *Scandinavian Journal of Public Health,* vol. 38, no. 3_suppl, pp. 149-155, 2010. https://doi.org/10.1177/1403494809354437

[65] S. Roopa and M. Rani, "Questionnaire designing for a survey," *Journal of Indian Orthodontic Society,* vol. 46, no. 4_suppl1, pp. 273-277, 2012.

[66] G. S. Maxwell, *Teacher observation in student assessment*. Brisbane: Queensland School Curriculum Council, 2001.

[67] E. Widodo and F. X. Sudarsono, "Developing an observation instrument for assessing the effectiveness of English teaching at vocational secondary schools," *Research and Evaluation in Education,* vol. 2, no. 2, pp. 135-154, 2016. https://doi.org/10.21831/reid.v2i2.8648

[68] B. Kartowagiran, E. A. Wibawa, F. Alfarisa, and D. N. Purnama, "Can student assessment sheets replace observation sheets?," *Cakrawala Pendidik,* vol. 38, no. 1, pp. 33–44, 2019. https://doi.org/10.21831/cp.v38i1.22207