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Fostering Prospective Science Teachers' Reading Comprehension and Critical Thinking Skills in Learning Cell Biology Through the Use of Directed Intervention Science Reading Activities for Thinking (DISRAT)

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Abstract: *The main concern of this research is improving prospective science teachers' reading comprehension and critical thinking skills in learning cell biology through the use of directed intervention science reading activities for thinking (DISRAT). This research was intended to find out whether directed intervention science reading activities for thinking (DISRAT) as intervention material could improve prospective science teachers' reading comprehension and critical thinking skills in learning cell biology. The research methodology was research and development and descriptive – evaluation research design. The subjects of this research were forty (40) third year prospective science teachers. The results of this research showed that the level of acceptability of developed directed intervention science reading activities for thinking (DISRAT) materials assesses by experts in terms of content; format and language; presentation and organization and; accuracy and up-to-datedness was observed as excellent material. Emergently, directed intervention science reading activities for thinking (DISRAT) for cell biology learning could improve prospective science teachers' significantly. It also revealed that directed intervention science reading activities for thinking (DISRAT) had a positive effect on the reading comprehension of the prospective science teachers', as evidenced by the significantly greater mean in the posttest. It is further proved with the hake gain score and t-test result. It is manifested that improve prospective science teachers' have very high observed critical thinking skills during the reading intervention on learning cell biology. Relatively, prospective science teachers' reading comprehension significantly high positive relationship to their critical thinking skills towards the implementation of directed intervention science reading activities for thinking (DISRAT) for cell biology. Future utilization of this directed intervention science reading activities for thinking (DISRAT) as a reading intervention material would raise students" reading comprehension and critical thinking skills in learning specific biology concepts.*

Keywords: *Cell Biology, Critical Thinking Skills, Directed Intervention Science Reading Activities for Thinking (DISRAT), Prospective Science Teachers', Reading Comprehension*

Introduction:

21st century learning directs learning using models that encourage students to think at a higher level. The development of education requires that every student has these skills. According to Fitriani, et al (2020) there are 7 skills needed by students to face the 21st century, including the ability to think critically and solve problems.

Looking on the Biology studies life and living organisms and since cells are the centerpiece of life, the cell is a fundamental concept in biology. The cell is the basic unit of function and structure in all living things, and the basis upon which all life forms is built (Fauzi, & Mitalistiaini, 2018).

It was evident that Biology learning has been carried out so far has not fully developed higher order thinking skills such as critical thinking, so that the learning process is expected to direct the development of higher order thinking skills (Nurkanti,et al, 2023). Learning biology should empower the mastery of critical thinking skills as one of the competencies students must have.

In undergraduate biology, the development of students' critical thinking is important, as its usage is integral to the nature of science. Through inquiry, scientists make observations about the world around them, formulate hypotheses as to why phenomena occur, design experiments to test predictions, and draw conclusions based upon the outcomes of research (Fausan, et al 2021)

Thus, because critical thinking is integral to the sciences, biology students who do not improve upon these skills during their schooling may not be able to acquire a basic competency needed to perform successfully in the discipline. Critical thinking is also important outside of the sciences; studies suggest that many students do not gain this important aptitude in their early collegiate years, and those with lower order thinking skills have worse employment and financial outcomes post-graduation (Huber, & Kuncel, 2016).

Taking aside, despite its relevance and importance, learning biology about the cell has been shown over time to be a difficult concept to master by biology students which needing some strategies in teaching process (Samosa, 2021a). Common issues faced by students when studying biology include misconceptions, biases, and abstract concepts that are difficult to understand such as processes of cell division, mitosis, meiosis, genetic material, haploid/diploid concepts, and the number of chromosomes is considered

complex, difficult to learn, and a challenge for students from elementary to higher education levels (Samosa, 2021b). In fact, understanding this subject has a direct correlation for further applications (Nerita & Safitri,2023).

Research conducted on meiosis is one of the central concepts in studying biology and genetics. However, this concept is often presented in textbooks as a rote list without a deep understanding (Murtonen, Nokkala, & Sodervik, 2020).

Some of the difficulties in understanding the concept of meiosis lie in the underlying concepts, namely, DNA, genes and chromosomes, the structures involved in meiosis, differences in chromosomes and chromatids, the stages of meiosis that occur, meiotic/mitotic division patterns, and the process of chromosomal separation and duplication (Fernández, & Tejada, 2018). Thus, if students study this content in depth, there is a high probability that these phases of the process will become poorly understood (Salleh, Ahmad, & Setyaningsih, 2021).

However, some misconceptions are usually persisted in the difficult (Putri, 2022). Specifically, in the material on cell division, there are issues with the inability of students to distinguish between replication, synapsis, and disjunction, determining whether this process occurs in mitosis, meiosis, or both (Frederick-Jonah, & Tobi, 2022).

Further misconceptions exist in the basic terms of a chromatid, chromosome, or chromosomal replication (Murtonen, Nokkala, & Sodervik, 2020). This material is the teacher's attention because the process of cell division is very important to understanding growth, development, reproduction, and genetics (Barke, & Buechter, 2023).

Some of the problems in the concept of protein synthesis include difficulties in studying the mRNA process, interpreting the symbolism of the DNA and RNA concepts, interpreting, and representing the orientation signals of DNA molecules 5'---3', translating the DNA replication process, and transcription/translation (Olimpo, Quijas, Quintana, 2017) Based on the research findings related to cell biology concepts that are difficult for students to understand, they are protein synthesis, cell division, cell metabolism, cell junction, and communication between cells.

In response with the educational hurdles encountered, teachers can use variety of teaching methodologies and instructional materials for effective learning. That is why, the researchers decided to utilize the directed intervention science reading activities for thinking (DISRAT) to test the effectiveness in enhancing the reading comprehension and critical thinking skills of the students in learning cell biology.

Meanwhile, in the era of information and knowledge, everyone seeks to develop his expertise by obtaining information and knowledge as much as and as quickly as possible. One of the ways to get information and knowledge is by reading. Therefore, the learning process, including biology learning, should be directed to encourage students to find out the various sources of available information by reading.

In a way, reading is the most effective learning activities because students can improve themselves regarding critical thinking, develop new and different perspectives, understand themselves and the world, and interpret events and situations they will face (Karadeniz, 2015).

Education leaders agree if some elements of the ability to think critically are also included in the elements of the ability to read well. Those elements are evaluation, analysis, making inferences, thinking inductive and deductive reasoning (Wanah et al, 2023). Reading not only involves the evaluation, analysis, and making conclusions, but also includes reasoning. Thorndike stated that the ability to read is an indicator of a person's ability to think and reason. Muslem, et al, (2017) explains that reading activity as mind process activation occurs through a series of very complex mental activity. Based on these explanations, it can be said that the process of reading is closely related to the development of thinking factors, including critical thinking.

On the same way, directed intervention science reading activities for thinking (DISRAT) was suited to helps students to form predictions as they read (Arisetyawati, 2017; Akamal, 2018; Utami & Sugirin, 2019). When finished reading a section of a text, students pause, check or amend their prior predictions, then create new ones about what they will read next.

More so, it promotes students' reading independence (Anandita, 2020). Students are actively involved in a process where they must use their own thoughts and logic (Safitri et al., 2022). Concomitantly, directed intervention science reading activities for thinking (DISRAT) model emphasizes the process of full student involvement to be able to find the material being studied and relate it to real-life situations so as to encourage students to be able to apply it in their lives (Nerim, 2020; Wijaya & Zulaeha, 2021).

As such concept, there are several things that can be observed. First, the directed intervention science reading activities for thinking (DISRAT) model emphasizes the direct experience process. The learning process in directed intervention science reading activities for thinking (DISRAT) does not expect students to only receive lessons, but the process of finding and finding the subject matter themselves.

Second, the directed intervention science reading activities for thinking (DISRAT) model encourages students to be able to apply it in life, meaning that the directed intervention science reading activities for thinking (DISRAT) model not only expects students to understand the material they are learning but how the subject matter can color their behavior in everyday life. day. The subject matter in the directed intervention science reading activities for thinking (DISRAT) model is not to be piled up in the brain and then forgotten, but as a provision for them to influence real life (Safitri et al., 2022).

In order for the improve reading comprehension and critical thing of the students in learning cell biology, teachers as a driving force for student learning are required to use the directed intervention science reading activities for thinking (DISRAT). From this, the researchers then try to see how the developed directed intervention science reading activities for thinking (DISRAT) can improve reading comprehension and critical thing of the students in learning cell biology.

OBJECTIVES

To the effectiveness of Directed Intervention Science Reading Activities for Thinking (DISRAT) to improve science prospective teachers reading comprehension and critical thinking skills in learning cell biology.

Specifically, it seeks to answer the following questions.

1. To determine the level of acceptability of the developed Directed Intervention Science Reading Activities for Thinking (DISRAT) materials as assessed by experts in terms of:
    - 1.1 Content;
    - 1.2 Format and Language;
    - 1.3 Presentation and Organization and;
    - 1.4 Accuracy and Up-to-datedness.
2. To examine the extent level of reading comprehension of prospective science teachers before and after the exposure of the directed intervention science reading activities for thinking (DISRAT)in terms of:
    - 1.1 Creative comprehension;
    - 1.2 Critical comprehension;
    - 1.3 Interpretative comprehension and;
    - 1.4 Literal comprehension.
3. To test the significant difference between the extent level of reading comprehension of prospective science teachers before and after the exposure of the directed intervention science reading activities for thinking (DISRAT)?
4. To determine the effectiveness of the directed intervention science reading activities for thinking (DISRAT) to improve science prospective teachers critical thinking skills in terms of:
    - 1.1 Open- mindedness;
    - 1.2 Truth – seeking;
    - 1.3 Analyticity;
    - 1.4 Systematicity;
    - 1.5 Self – confidence;
    - 1.6 Inquisitiveness and
    - 1.7 Cognitive maturity.
2. To test the significant relationship between the science prospective teachers reading comprehension and critical thinking skills.

THEORETICAL FRAMEWORK

To provide the theoretical bases for this study, Jerome Bruner's theory of constructivism and Vygotsky's Zone of Proximal Development were considered in discussing the process of developing instructional materials for Directed Intervention Science Reading Activities for Thinking (DISRAT) in learning cell biology.

This study on the development of instructional material for Directed Intervention Science Reading Activities for Thinking (DISRAT) in learning cell biology is supported by Jerome Bruner's constructivist theory. This view has heavily influenced both the teaching-learning process. Bruner’s theory of constructivism denotes that "learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledge"(Bruner,1996). He also added that selection and transformation of information, construction of hypotheses, decision-making are done by the learners as they rely on a cognitive structure.

In addition, Metsämuuronen and Räsänen, (2018) stressed that constructivism is used for scientific research, communication, reading, learning, and teaching and it involves essential aspects such as culture, context, literacy, language, learners' interests and needs, personal experiences, interpretation of reality, as well as application of knowledge. Thus, the application of a constructivist approach and the provision of learning activities in a constructivist setting that is characterized by active engagement, inquiry, problem-solving, and collaboration with others will help fulfill the learners' reading comprehension and critical thinking skills.

On the other hand, Vygotsky’s zone of proximal development, to define, refers to “the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peer" (Silalahi, 2019). Further, following the principles of Vygotsky's ZPD, the development of Directed Intervention Science Reading Activities for Thinking (DISRAT) in learning cell biology shall consist of activities that will require learners’ large participation under the guidance of the teacher or a more competent person and eventually put them in the process wherein they will be working independently without the teacher scaffolding.

Hence, the application of Vygotsky’s scaffolding approach to instruction will be evident in facilitating students’ learning critical thinking skills, to comprehend on the text related to subject matter and in the developed activities wherein learners are provided with several exercises and learning tasks that they will be performing independently and collaboratively with peers and teachers when needed.

RESEARCH METHODOLOGY

This portion presents the research methodology that will be utilized by the researchers in the study. The discussion will focus on the research design, the sample and sampling procedure, the instrument used in the study, the data gathering procedure and the statistical tool that will be utilized in the study.

RESEARCH DESIGN

This studied employs a research and development and descriptive – evaluation research design.

R & D design was appropriate because it helped create and extend knowledge about developing, enacting, and sustaining innovative learning environments (Samosa, 2020c). R & D design has many advantages over experimental research; the research is carried out in real life setting where learning is done, it characterizes the situation with all its complexity it involves different participants in the design who bring in differing expertise instead of being subjects of study. It is a flexible design for revision in which tentative initial set is revised depending on success. The guidelines for the R & D design of the instructional materials were based on ADDIE instructional design model which provide procedural framework for the systematic production of instructional materials. ADDIE instructional design model it is one of the systematic learning design models, chosen based on the consideration of this model is developed systematically and rests on the theoretical foundation of learning design. This model is structured programmed with sequences of systematic activities in efforts to solve learning problems related to learning resources that are in accordance with the needs and characteristics of students. This model consists of five steps, namely: (1) analyze, (2) design, (3) development, (4) implementation, and (5) evaluation. Evaluation in ADDIE model has been done step by step.

Analysis. At the first step, activity done such as (1) analyzing the competencies must be mastered by the students in cell biology based on the course syllabus, (2) analyzing the students characteristics relate to their knowledge, attitudes, and skills and (3) analyzing the relevant materials to the competency achievements desired relate to what students' master. Analysis result of this step is self-evaluated and continued evaluation with colleagues for the improvement of analysis results.

Design. The second step is focused on three activities those are material choice relevant to the students' characteristics and the competence to be achieved, learning strategy, assessment form and method and also evaluation. In this step, Directed Intervention Science Reading Activities for Thinking (DISRAT) structure and content framework are designed. The result will be self- evaluated and also with colleagues for the improvement of design results.

Development There are several activities such as (1) Create factual sample for the instruction design; collecting relevant data resources to enrich the Directed Intervention Science Reading Activities for Thinking (DISRAT), (2) Develop the materials of the course; making illustration, scheming, and creating graph needed, typing, editing, and also laying out the Directed Intervention Science Reading Activities for Thinking (DISRAT) is performed, (3) Run through the conduction of the design; validating the draft of development product and revision after expert input will be performed.

Implementation. In this step, development result is applied in learning process to know its influence on the quality of learning covers the effectiveness, attractiveness, and efficiency. Implementation is applied on small group to get input from the students and lecturers as input for the revision of product draft.

Evaluation. The last step is evaluation covers formative and summative evaluations. Formative evaluation is performed to collect data on every step used to the improvement. Summative evaluation is done in the end of the program to know its influence on students learning outcome and the quality of learning extensively. This research only applies formative evaluation because this evaluation relates to the steps of development research to uplift development product resulted. Evaluation in ADDIE model has been done step by step.

More so, the appropriate method for addressing the aim of the study to examine the effectiveness of Directed Intervention Science Reading Activities for Thinking (DISRAT) to improve science prospective teachers reading comprehension and critical thinking skills in learning cell biology were descriptive – evaluation research design. Samosa et al (2021a) pointed out that descriptive evaluation design aim to provide information for decision maker (policy maker) related to a power or strength of a policies, program, intervention, remediation, and innovation seen from its effectiveness, cost, device, etc. This study stands for the belief that the descriptive – evaluation design provides more relevant findings to give a wider view whether a process has yielded the desired result(s) and to employed for Directed Intervention Science Reading Activities for Thinking (DISRAT) to its effectiveness to science prospective teachers reading comprehension and critical thinking skills in learning cell biology.

THE SAMPLE AND SAMPLING PROCEDURE

The researchers utilized the purposive sampling technique to determine the respondents of the study. The researchers used the purposive sampling in the study to secure a controlled data collection as well as interpretation pertaining to the commonalities or differences of answers by said sample population. Relatively, it will be very convenient on the part of the researchers to make sure that the data to be collected are all coming from the same nature or groups. The respondents are carefully chosen in accordance with the criteria who are science prospective science teachers in University in Cavite for the school year 2023 -2024. This was affirmed on the writings of Samosa et.al (202b), wherein it was pointed out that purposive sampling is a form of non-probability sampling in which decisions concerning the individuals to be included in the sample are taken by the researcher, based upon a variety

of criteria which may include specialist knowledge of the research issue, or capacity and willingness to participate in the research. The respondents of this study where the forty (40) prospective science teachers were purposively chosen as the respondents of the study who are (1) enrolled in the course of cell and molecular biology (2) belong to least mastered students in the course (3) identified problems in reading comprehension and critical thinking test.

RESEARCH INSTRUMENTS

The researchers utilized the following instruments to collect data needed to achieve the objectives of the study.

Learning Resource Validation Form was used to gather the level of acceptability of the developed Directed Intervention Science Reading Activities for Thinking (DISRAT) materials in terms of content; format and language; presentation and organization and; accuracy and up-to-datedness. Each variable considered ten (10) indicators.

Reading Comprehension Test in Cell biology. This comprises items that measure the reading comprehension of science pre-service teachers in their cell biology class, particularly in understanding concepts of a cell. The questionnaire is composed of passages about a cell and 30 multiple-choice items. This instrument was validated by three professionals and experts in the field of Biology education, language education, and tool development. Further, it was pilot tested to determine the reliability of the instrument before its conduct to the main study. The reliability test was performed to determine the consistency of the ratings performed by the researchers and inter-raters. The results of the inter-raters reliability test was with a Kappa value of 95.33% reported excellent.

Critical Thinking Skills Survey Questionnaire. It used to gather the critical thinking skills of the science pre-service teachers in terms of open- mindedness; truth – seeking; analyticity; systematicity; self – confidence; inquisitiveness and cognitive maturity. Each variable considered five (5) indicators. Suggestions from the experts were considered for the final draft of the survey questionnaire. After establishing the validity, it was pilot tested on 30 nonrespondents to determine its reliability. Using Cronbach's alpha, the computed reliability was .93, thus means the instruments were reliable.

DATA GATHERING PROCEDURES

A letter was given to the three professionals and experts in the field of Biology education, language education, and tool development to validate the instruments. The expert rated the questionnaire to establish its content validity.

Samosa and Dantay (2022) said that content validity chiefly targets the usefulness, originality, and representativeness of the test items to assess the characteristics to look for. This is usually done when a group of experts in the field of interest has inspected the test items.

Once all procedures for validity and reliability were considered, the research questionnaire and pretest-posttest were administered to select participants. As regards data gathering procedures, the researchers would apply for approval and submit a formal letter to survey the Dean of the school, the department head of the program, and the adviser of the third-year students of Bachelor of Secondary Education major in science from a University in Cavite, Philippines. The respondents hailed from the third year of their Bachelor of Secondary Education major in science. They were chosen using a total population sampling method as the researchers chose the specific group of people as the respondents met the requirements and specifications necessary for the researchers to gather enough data. Then, it also asked the subjects/respondents to participate in answering the questionnaire. The subjects/respondents were informed of their anonymity and confidentiality in the study, and the subjects were also informed of their rights to withdraw at any moment if any of their rights were violated. The completion of the survey is equal to consent to the participation. Meanwhile, Directed Intervention Science Reading Activities for Thinking (DISRAT) in learning cell biology was selected following the intended instructional purposes and the students' characteristics and interests before learning.

Another criterion for choosing Directed Intervention Science Reading Activities for Thinking (DISRAT) in learning cell biology it is comprehension strategic materials that guides students in asking questions about a text, making predictions, and then reading to confirm or refute their predictions. The DISRAT in process encourages students to be active and thoughtful readers, enhancing their comprehension. The following are the procedure used in the implementation of the Directed Intervention Science Reading Activities for Thinking (DISRAT). First, determine the text to be used and pre-select points for students to pause during the reading process. Then, introduce the text, the purpose of the DISRAT, and provide examples of how to make predictions. In the implementation of the Directed Intervention Science Reading Activities for Thinking (DISRAT) it considers the following steps: (1) Activate the students' thinking prior to reading a passage by scanning the title, chapter headings, illustrations, and other materials. Use open-ended questions to direct students as they make predictions about the content or perspective of the text. (2) Students read up to the first pre-selected stopping point. The teachers then prompt the students with questions about specific information and ask them to evaluate their predictions and refine them if necessary. This process should be continued until students have read each section of the passage. (3) At the end of each section, students go back through the text and think about their predictions. Students should verify or modify their predictions by finding supporting statements in the text.

The topics covered in the implementation of the Directed Intervention Science Reading Activities for Thinking (DISRAT) in learning cell biology were based on syllabus given at the start of the semester. After the exposure, the collection of needed data would then be conducted in two phases, and the collected data would be processed by appropriate statistical treatment. The results would be summarized, and the data collected on each question would be tallied and tabulated.

DATA ANALYSIS

Data gathered from this study were subjected to the following statistical treatments:

Weighted Mean. The weighted mean was use to assess the level of acceptability of the developed Directed Intervention Science Reading Activities for Thinking (DISRAT) materials in terms of content; format and language; presentation and organization and; accuracy and up-to-datedness. This addresses the objective 1. More so, it also measured the critical thinking skills of the science pre-service teachers in terms of open- mindedness; truth – seeking; analyticity; systematicity; self – confidence; inquisitiveness and cognitive maturity. This addresses the objective 4.

Table 1
Likert Scale

Scale	Acceptability Level of DISRAT	Critical Thinking Skills
4.20 – 5.00	Highly Acceptable	Very high Observed
3.40 – 4.19	Acceptable	Highly Observed
2.60 – 3.39	Moderately Acceptable	Observed
1.80 – 2.59	Less Acceptable	Moderately Observed
1.00 – 1.79	Not Acceptable	Not Observed

Percentage Mean. It measures the described the level of reading comprehension of the students in terms of creative comprehension, critical comprehension, interpretative comprehension, and literal comprehension. This address objective 2. More so, **Hake gain score** was used to evaluate student improvement when a test is administered at the beginning (pre-test) and at the end (post-test) of a course.

Table 2
Level of Reading Comprehension

Mean Percent Scores	Level	Qualitative Description
Higher than 74	Mastery	Generally, students found reading relatively easy with a deep (fully developed comprehension of the reading selection.
50 -74	Near Mastery	In general, students comprehend reading selection but need to be developed
Lower than 50	Low Mastery	In totality, students portray a low level of reading comprehension. Further, they need much attention in developing their reading comprehension.

Table 3
Hake Gain Score

Scale	Level of Improvement/Effectiveness
G > 70%	High Effective
30% < G < 70%	Moderately Effective
G < 30%	Low Effective

t-test of dependent sample. It was used to test the inference on the significant difference between the extent level of reading comprehension of prospective science teachers before and after the exposure of the directed intervention science reading activities for thinking (DISRAT). This address objective 3.

Pearson r. It is used to measure the significant relationship between the science prospective teachers reading comprehension and critical thinking skills. This address objective 5.

RESULTS AND DISCUSSIONS

To ensure transparency and accuracy, the data obtained in this analysis was thoroughly analyzed and interpreted.

1. Level of Acceptability of the Developed Directed Intervention Science Reading Activities for Thinking (DISRAT)

Presented on the tables were the summary of the evaluation of experts on the extent level of acceptability of the developed directed intervention science reading activities for thinking (DISRAT) in terms of content; format and language; presentation and organization and accuracy and up-to-datedness.

Table 4
Summary of the Assessment in the Level of Acceptability of the Developed Directed Intervention Science Reading Activities for Thinking (DISRAT)

No	Level of Acceptability of the Developed Directed Intervention Science Reading Activities for Thinking (DISRAT)	WM	Verbal Interpretation
1	Content	4.83	Highly Acceptable
2	Format and Language	4.39	Highly Acceptable
3	Presentation and Organization	4.51	Highly Acceptable
4	Accuracy and Up-to-datedness.	4.59	Highly Acceptable
	Overall	**4.58**	Highly Acceptable

The Table 4 entails the level of acceptability of the developed directed intervention science reading activities for thinking (DISRAT) as assessed by experts. The data revealed that content; format and language; presentation and organization and accuracy and up-to-datedness obtained highly acceptable based on the computed scores of 4.83, 4.39, 4.51, and 4.59 respectively. The overall assessments gained 4.58 will be interpreted as highly acceptable. This implies that the validators highly agree that the reading material is presented in a way that it will serve its purpose to the readers, it is followed by content; format and language; presentation and organization and accuracy and up-to-datedness. It means that the language used in the reading material is easy to comprehend and can be easily understood. More so, the skills or topics of the intervention materials were needed to be mastered by the learners to enhance their reading comprehension skills and critical thinking in learning cell biology.

It also portrayed in the findings of Carillaga (2022), that the intervention material/reading material are delivered best because of their content and purposes, most importantly, if validated. Proportionally, the produce materials one in which the line-up of activities was carefully chosen, designed with the required objectives, and created to fit a particular format and approach.

2. Extent Level of Reading Comprehension of Science Prospective Teachers Before and After the Exposure of the Directed Intervention Science Reading Activities for Thinking (DISRAT)

Table 5
Extent Level of Reading Comprehension of Prospective Science Teachers Before and After the Exposure of the Directed Intervention Science Reading Activities for Thinking (DISRAT)

Variables	Pretest	Verbal Interpretation	Posttest	Verbal Interpretation	Hake Gain Score	Verbal Interpretation
Creative comprehension	33.43	Low Mastery	81.83	Mastery	72.70	High Effective
Critical comprehension	38.63	Low Mastery	90.03	Mastery	83.75	High Effective
Interpretative comprehension	35.33	Low Mastery	91.15	Mastery	86.31	High Effective
Literal comprehension	34.88	Low Mastery	90.63	Mastery	85.61	High Effective
Overall	**35.57**	**Low Mastery**	**88.41**	**Mastery**	**82.09**	**High Effective**

Table 5 presents the pretest and posttest scores of prospective science teachers in reading comprehension in terms of creative comprehension, critical comprehension, interpretative comprehension, and literal comprehension when exposed to directed intervention science reading activities for thinking (DISRAT), the results of the pretests were 33.43, 38.63, 35.33 and 34.88 respectively. More so, the posttest scores were 81.83, 90.03, 91.15, and 90.63 respectively. Therefore, the gain score was 72.70, 83.75, 86.31, and 85.61 respectively. As evidence, it can be noted that using the directed intervention science reading activities for thinking (DISRAT) was observed to be high effective in improving the reading comprehension in learning cell biology among

prospective science teachers. It was observable on the overall posttest score of 88.41 which was greater than the overall pretest score of 35.57. The overall gain scores were 82.09 and interpreted as high effective. Relatively, it can be culled that directed intervention science reading activities for thinking (DISRAT) for cell biology had a positive effect on the reading comprehension in learning cell biology among prospective science teachers, as evidenced by the significantly greater mean in the posttest than in the pretest.

From this finding confirmed studies of Panjaitan and Siagian (2019), that directed intervention science reading activities for thinking (DISRAT) made positive effects on student reading comprehension.

3. Test the significant difference between the extent level of reading comprehension of science prospective teachers before and after the exposure of the directed intervention science reading activities for thinking (DISRAT)

Table 6
Test of Difference in the Extent Level of Reading Comprehension of Prospective Science Teachers Before and After the Exposure of the Directed Intervention Science Reading Activities for Thinking (DISRAT)

Variables	t-test computed value	T-test critical value	P – value	Decision	Verbal Interpretation
Creative comprehension	31.17	1.68	0.00	H_o is rejected	Significant
Critical comprehension	52.98	1.68	0.00	H_o is rejected	Significant
Interpretative comprehension	48.00	1.68	0.00	H_o is rejected	Significant
Literal comprehension	61.61	1.68	0.00	H_o is rejected	Significant

df = 39

Reflected on the table below is the analysis on the assessment of the pretest-posttest of the reading comprehension of the prospective science teachers in learning cell biology. The test of inference to determine the significant difference on the pretest-posttest of the reading comprehension of the prospective science teachers, the researchers employed the t-test for dependent sample to compare the observations or measurements on a single characteristic and draws decision as to whether there is a significant difference present among the set of scores for every variable considered. Considerably, the conduct of the test of inference considered for the level of significance at 0.5, two-tailed with a degree of freedom (df) of 39 and the corresponding tabular t-value.

Looking at table 6, it shows that the gathered data for reading comprehension of prospective science teachers before and after the exposure of the directed intervention science reading activities for thinking (DISRAT) in terms of creative comprehension, critical comprehension, interpretative comprehension, and literal comprehension reflects the computed t-values was 31.17, 52.98, 48.00 and 61.61 respectively, which is greater than the tabular-t value of 1.68, this reflects that the null hypothesis is rejected, thus there is a significant difference on the on the assessment of the pretest-posttest of the reading comprehension of the prospective science teachers in creative comprehension, critical comprehension, interpretative comprehension, and literal comprehension. Hence, it is evident that there was an improvement after the utilization of directed intervention science reading activities for thinking (DISRAT) in improving the reading comprehension of the prospective science teachers. This finding affirmed with the stand of Sa'diah (2023) that directed intervention science reading activities for thinking (DISRAT) improved the students reading comprehension in learning science subjects. The discoveries of this exploration confirm the ones of past investigations done by Sudirman, and Firman (2019) that the effect of directed intervention science reading activities for thinking (DISRAT) lead to the students to have prediction before reading, create background knowledge, analyzing the fact to support the prediction, confirming the prediction and evaluating the text and context in order to have comprehensive comprehension in learning science subjects.

4. Effectiveness of the Directed Intervention Science Reading Activities for Thinking (DISRAT) to Improve Prospective Science Teachers Critical Thinking Skills

Presented on the tables were the summary of the evaluation of the effectiveness of the Directed Intervention Science Reading Activities for Thinking (DISRAT) to improve science prospective teachers critical thinking Skills in terms of open- mindedness; truth – seeking; analyticity; systematicity; self – confidence; inquisitiveness and cognitive maturity.

Table 7
Summary of the Assessment in the Prospective Science TeachersCritical Thinking Skills

No	Critical Thinking Skills	WM	Verbal Interpretation
1	Open- mindedness	4.36	Very High Observed
2	Truth – seeking	4.21	Very High Observed
3	Analyticity	4.48	Very High Observed
4	Systematicity	4.67	Very High Observed
5	Self – confidence	4.77	Very High Observed
6	Inquisitiveness	4.81	Very High Observed
7	Cognitive maturity	4.67	Very High Observed
	Overall	**4.57**	**Very High Observed**

Table 7 indicates the critical thinking skills of the prospective science teachers in terms of open- mindedness; truth – seeking; analyticity; systematicity; self – confidence; inquisitiveness and cognitive maturity. The gathered data revealed that prospective science teachers attained very high observed in critical thinking skills as gleaned in the computed weighted means of 4.36, 4.21, 4.48, 4.67, 4.77, 4.81, and 4.67 respectively. The overall computed weighted mean was 4.57 likewise interpreted as very high observed. This study's findings suggest that the Directed Intervention Science Reading Activities for Thinking (DISRAT) is an effective one for critical thinking skills.

Other researchers also found a similar result who studied the implementation of Directed Intervention Science Reading Activities for Thinking (DISRAT) to improve critical thinking.

Novendiana, Tasnim, & Wijaputra (2016) found that the implementation of Directed Intervention Science Reading Activities for Thinking (DISRAT) can improve both their reading comprehension and critical thinking of the students.

A similar finding was also found by Sefrianah, Suyono, and Andajani (2018) that Directed Intervention Science Reading Activities for Thinking (DISRAT) significantly affects students' critical thinking in junior high school and senior high school levels.

Directed Intervention Science Reading Activities for Thinking (DISRAT) can improve students' critical thinking because it consists of understanding and practice. According to Mehta & Al-Mahrouqi (2014), critical thinking can be taught through drills, exercises, and problem-solving. This is confirmed by Abrami, et al. (2015), who found that critical thinking improvement can be obtained with appropriate instructional strategies. Thus, the Directed Intervention Science Reading Activities for Thinking (DISRAT) can improve students' critical thinking because it engages students to be active and interactive during the teaching and learning process. Besides, the Directed Intervention Science Reading Activities for Thinking (DISRAT) strategy can make students build their critical thinking because, at the time of implementing this strategy, students will be invited to predict and confirm the predictions they have previously made.

Table 8
Test the Significant Relationship Between the Prospective Science Teachers Reading Comprehension and Critical Thinking Skills

Variables	Pearson r	Relationship	df	t-test computed value	t-test critical value	P – value	Decision	Verbal Interpretation
Reading comprehension and Critical Thinking skills	0.91	Very High Positive	38	13.53	2.021	0.00	H_o is rejected	Significant

The data revealed that the obtained pearson r value is 0.91 which denotes very high positive relationship. This means the higher the reading comprehension, the higher is the level of critical thinking skills towards the utilization of directed intervention science reading activities for thinking (DISRAT). Since the t- value, 13.53 is greater than the t- critical value, 2.021 at 0.05 and degree of freedom of 38, giving the researcher reasons to reject the null hypothesis in favor of researchers' hypothesis. This may be safely concluded that prospective science teachers reading comprehension was significantly related to the critical thinking skills towards the implementation of directed intervention science reading activities for thinking (DISRAT) in learning cell biology.

For students to get used to conceptual understanding by reading the materials, critical thinking skills must be trained and honed by providing continuous stimulus and training (Hidayati et al., 2021). This argued that subject comprehension plays a key role in developing critical-thinking skills (Paige, Rupley, & Ziglari,2024). Then, critical thinking skills affect the literacy skills of students towards learning the subject areas (Ristanto et al., 2018). It was also supported by findings of Ristanto, Miarsyah, & Fitrianingtyas, (2023) that the ability to think critically of the students are also included in the elements of the ability to read well.

CONCLUSIONS

The data yield that the level of acceptability of developed directed intervention science reading activities for thinking (DISRAT) materials assesses by experts was observed as highly acceptable material. It was found that the Directed Intervention Science Reading Activities for Thinking (DISRAT) can improve students' reading comprehension and critical thinking. This study's results can be seen from the increase in the value of students' reading comprehension and critical thinking from before the implementation of directed intervention science reading activities for thinking (DISRAT) was observed.

From these results, to improve the quality of the cell biology and learning process of prospective science teachers especially in improving reading comprehension and critical thinking skills, the researchers suggests (1) Professors/Instructors should always prepare texts that can attract students' attention and are suitable for teaching reading and critical thinking skills, 2) Professors/Instructors must implement appropriate learning strategies that can improve students' reading and critical thinking skills, 3) If the Professors/Instructors uses directed intervention science reading activities for thinking (DISRAT), the teacher must prepare himself and all the pedagogical approaches needed to achieve maximum results, 4) The directed intervention science reading activities for thinking (DISRAT) can be an alternative strategy for teaching reading and critical thinking skills because it has been proven to be empirically effective.

REFERENCES

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. Review of Educational Research, 85(2), 275 –314.

Akmal, A. (2018). The Effects of Directed Reading Activity Strategy (DRTA) in Descriptive Reading Texts. Journal of Science and Social Research, 1(2), 116-121. https://doi.org/10.54314/jssr.v1i2.212.

Anandita, S. R. (2020). Improving Reading Comprehension Ability of the Eleventh Grade Students of MAN 5 Jombang through Jigsaw Technique. JoEMS (Journal of Education and Management Studies), 3(2), 37-42.

Arisetyawati, S. K. (2017). The Effect of Directed Reading Thinking Activity In Cooperative Learning Setting Toward Students' Reading Comprehension Of The Eleventh Grade Students. Journal of Psychology and Instruction, 1(2), 88-96.

Barke, H. D.; and Buechter, J. (2023). Laboratory jargon and misconceptions in chemistry an empirical study. ASEAN Journal of Science and Engineering Education, 3(1), 65-70.

Carillaga, J. M. (2022). Validation Of Enhancement Tool for Reading Comprehension Skill. *EPRA International Journal of Multidisciplinary Research (IJMR)*, *8*(7), 1-10.

Fauzi, A., & Mitalistiaini, M. (2018), High school biology topics that perceived difficult by undergraduate students. Didakika Biologi: Jurnal Penelitian Pendidkan Biologi, 2(2), 73-84. https://doi.org/10.32502/dikbio.v2i2.1242.

Fausan, M. M., Susilo, H., Gofur, A., Sueb, S., & Yusop, F. D. (2021, March). Assessing students' prior knowledge on critical thinking skills in the biology classroom: Has it already been good?. In *AIP Conference Proceedings* (Vol. 2330, No. 1). AIP Publishing.

Fernández, M. D. M. F., & Tejada, M. P. J. (2018). Difficulties learning about the cell. Expectations vs. reality. *Journal of Biological Education*.

Fitriani, A., Zubaidah, S., Susilo, H., & Al Muhdhar, M. H. I. (2020). The correlation between critical thinking skills and academic achievement in biology through problem based learning-predict observe explain (pblpoe). *International Journal of Learning and Teaching*, *6*(3), 170-176.

Frederick-Jonah, T. M., & Tobi, T. (2022). Areas and causes of students' difficulties in learning the concept of cell in secondary school biology curriculum. *International Journal of Advanced Academic Research*, *8*(3), 16-27.

Huber, C. R., & Kuncel, N. R. (2016). Does college teach critical thinking? A meta-analysis. *Review of Educational Research*, *86*(2), 431-468.

Mehta, S. R., & Al-Mahrouqi, R. (2014). Can thinking be taught? lLnking critical thinking and writing in an EFL context. RELC Journal, 1-14.

Metsämuuronen, J., & Räsänen, P. (2018). Cognitive–linguistic and constructivist mnemonic triggers in teaching based on Jerome Bruner's thinking. *Frontiers in psychology*, *9*, 351697.

Murtonen, M.; Nokkala, C.; and Sodervik, I. (2020) Challenges in understanding meiosis: Fostering metaconceptual awareness among university biology students. Journal of Biological Education , 54(1), 3-16.

Muslem, A., Usman, B., Fitriani, S. S., & Velayati, N. (2017). Critical Thinking Skills Used among University Students in Reading Comprehension. *Anatolian Journal of Education*, *2*(2), 40-54.

Nerim, N. (2020). Scrutinizing directed reading thinking activity (drta) strategy on students'reading comprehension. Journal of Languages and Language Teaching, 8(2), 128-138.

Nerita, S., & Safitri, E. (2023). Analysis of Student Difficulties in Learning Biology. *Journal Of Biology Education Research (JBER)*, *4*(1), 1-8.

Novendiana, F. H., Tasnim, Z., & Wijaputra, B. A. (2016). The effect of using directed reading thinking activity (drta) strategy onthe tenth grade students' reading comprehension achievement at MA Unggulan Nuris Jember. Jurnal Edukasi, 3(3), 43-46.

Nurkanti, M., da Silva Santiago, P. V., Yasundari, Y., & Rohimah, S. M. (2023). Developing students' critical thinking abilities using the English literacy comprehension Journal: A case study in Biology Education. *AMCA Journal of Science and Technology*, *3*(2), 43-46.

Olimpo, J.T.; Quijas, D.A.; Quintana, A.M. (2017). A focus on polarity: Investigating the role of orientation cues in mediating student performance on mRNA synthesis tasks in an introductory cell and molecular biology course. Biochemistry and Molecular Biology Education, 45(6), 501-8.

Paige, D., Rupley, W. H., & Ziglari, L. (2024). Critical Thinking in Reading Comprehension: Fine Tuning the Simple View of Reading. *Education Sciences*, *14*(3), 225.

Panjaitan, N. B., & Siagian, Y. L. (2019). The Use of Directed Reading Thinking Activity Strategy To Enhance Students'reading Comprehension. In *Abstract Proceedings International Scholars Conference* (Vol. 7, No. 1, pp. 2176-2190).

Sa'diah, K. (2023, December). The Teaching Reading Comprehension Through Direct Reading Thinking Activity (DRTA) Strategy at The First Grade Of SMP Plus Bustanul Ulum Puger-Jember. In *2nd Annual Conference of Islamic Education 2023 (ACIE 2023)* (pp. 83-89). Atlantis Press.

Safitri, M., Marhaban, S., & Erdiana, N. (2022). A review of Directed Reading Thinking Activity (DRTA) strategy in teaching reading comprehension. English Education Journal, 13(2), 290-303. https://doi.org/10.24815/eej.v13i2.25910

Salleh, W. N. W. M., Ahmad, C. N. C., & Setyaningsih, E. (2021). Difficult topics in Biology from the view point of students and teachers based on KBSM implementation. *EDUCATUM Journal of Science, Mathematics and Technology*, *8*(1), 49-56.

Samosa, R. C. (2021a). Cooperative Learning Approach as Innovation to Improve Students' Academic Achievement and Attitude in Teaching Biology. *Journal of World Englishes and Educational Practices*, *3*(1), 01-10.

Samosa, R. C.(2021b). COSIM (Comics Cum Sim): an Innovative Material in Teaching Biology. *European Journal of Research Development and Sustainability*, *2*(4), 19-28.

Samosa, R C. (2020c). Understanding the End- to – End Praxis of Quantitative Research: From Scratch to Paper Presentation. *Book of Life Publication*.

Samosa, R. C, Magulod, G. C., Jr., Capulso, L. B., Delos Reyes, R. J. V., Luna, A. R. F., Orte, C. J. S., Maglente, S. S., Pentang, J. T., Olitres, B. J. D., & Vidal, C. J. E. (2021a). How to Write and Publish Your Thesis. *Beyond Books Publication*.

Samosa, R. C, Magulod, G. C., Jr., Capulso, L. B., Delos Reyes, R. J. V., Luna, A. R. F., Orte, C. J. S., Maglente, S. S., Pentang, J. T., Olitres, B. J. D, & Vidal, C. J. E. (2021b). How to Write and Publish Your Dissertation. *Beyond Books Publication*.

Samosa, R. C. & Dantay, R. M. (2022). Demystifying Action Research Manual for Basic Education Teachers: From Proposal to Presentation. *Poetry Planet Book Publishing House*.

Sefrianah, N. A., Suyono, S., & Andajani, K. (2018). pengaruh strategi DRTA terhadap kemampuan berpikir kritis siswa jenjang SD, SMP, dan SMA. Jurnal Pendidikan: Teori, Penelitian, & Pengembangan, 3(2), 229-237.

Silalahi, R. M. (2019). Understanding Vygotsky's zone of proximal development for learning. *Polyglot: Jurnal Ilmiah*, *15*(2), 169-186.

Sudirman, S., & Firman, E. (2019). A Directed Reading-Thinking Activity (Dr-Ta) Towards Students 'Critical Reading. *JISIP (Jurnal Ilmu Sosial dan Pendidikan)*, *3*(3).

Tipmontiane, K.; and Williams, P. J. (2022). The integration of the engineering design process in biology-related STEM activity: A review of Thai secondary education. ASEAN Journal of Science and Engineering Education, 2(1), 1-10.

Utami, Y. P., & Sugirin, S. (2019). Fostering Students' Reading Comprehension Ability through Directed Reading Thinking Activities (DRTA) Strategy. Journal of English Language Teaching and Linguistics, 4(2), 129.

Wanah, H. N., Jamaluddin, A. B., Zahra, F., Zubaidah, S., & Arsih, F. (2023, January). Critical thinking, communication skills and biology learning outcomes: Are they correlated?. In *AIP Conference Proceedings* (Vol. 2569, No. 1). AIP Publishing.

Wijaya, P. A., & Zulaeha, I. (2021). The Influence of Direct Reading Thinking Activity (DRTA) Strategy and Know-Want to Know-Learned (KWL) Strategy on Reading Comprehension Skills. Journal of Primary Education, 10(3), 284-296.