EDUCATUM JSMT Volume 11 Number 1 (2024)
ISSN 2289-7070 / e-ISSN 2462-2451 (23-35)
https://ejournal.upsi.edu.my/index.php/EJSMT/index

Interactive and Indirect Instruction in Developing Critical Thinking Skills of Grade 10 in a Flipped Science Classroom

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Published: 16 January 2024

To cite this article (APA): Borja, C. A., & Panoy, J. F. (2024). Interactive and Indirect Instruction in Developing Critical Thinking Skills of Grade 10 in a Flipped Science Classroom. *EDUCATUM Journal of Science, Mathematics and Technology*, *11*(1), 23–35. https://doi.org/10.37134/ejsmt.vol11.1.4.2024

To link to this article: https://doi.org/10.37134/ejsmt.vol11.1.4.2024

Abstract

This study determined the effectiveness of interactive and indirect instruction in developing critical thinking skills among Grade 10 students of Sta. Anastacia – San Rafael National High School in a flipped science classroom. A quasi-experimental research design through pre-test and post-test strategies was utilized. The pre-test and post-test results measured the effectiveness of the flipped teaching strategies in developing the critical thinking skills of grade 10 learners and identify whether significant differences exist between the pre-test and post-test scores of the respondents exposed to interactive and indirect instruction. The findings indicated that four variables of critical thinking skills showed no significant difference in terms of the pre-test scores of the respondents. Moreover, there is a significant difference between the pre-test and post-test scores of the respondents in the different critical thinking skills as they are exposed to flipped teaching strategies specifically interactive and indirect instruction. The study also revealed that there is a significant difference in the post-test scores of the respondents in terms of inference, explanation, and interpretation after the implementation of the different flipped teaching strategies except for self-regulation. The findings suggest the use of interactive and indirect instruction as flipped teaching strategies in teaching science to improve students' performance and develop the critical thinking skills of learners.

Keywords critical thinking skills, flipped science classroom, indirect instruction, interactive instruction

INTRODUCTION

One of the significant aims of education is to produce learners who have the appetite to think critically. Students nowadays are having insufficient critical thinking skills which are essential in making decisions, judgment and understanding science concepts. As such, a learner who is taught to think critically develops an interest in what is going on around him/her. Students that are deeply and genuinely curious desire to examine and digest information and experiences. This means that developing these students' skills enables them to understand the knowledge or science concepts.

Critical thinking is self-disciplined, self-monitored, and self-corrective thinking. When one thinks critically, it is done on one's initiative. There is an internalization of the subject at hand, as well as an objective understanding of it. Critical thinking is crucial to learning because it allows learners to reflect on and understand their points of view. Based on personal observation and comprehension, this skill assists a student in determining how to make sense of the world. It boosts learners' self-esteem and confidence since they know the output is the product of a mental process that produces results. Students gain confidence as well as the ability to learn from their mistakes, which is useful in both their personal and professional lives.

The flipped classroom learning approach is one of the emerging ideas in education. Clark-Ibnáez and Scott (2010) define flipped learning as an educational technique that leverages blended information to streamline the structure of the traditional classroom paradigm. The flipped classroom aims to shift the emphasis to the students. With flipped instruction, students have more time to collaborate, more time to differentiate instruction, are more active when learning science, and have a more individualized learning experience, overall. Further, it may give the opportunity for the teachers to give extra assistance to students during class which could result in better performance.

Critical thinking is usually taught and practiced in a formal educational system. Teachers incorporate this ability in the teaching-learning process since they are one of the key contributors of knowledge and hence accountable for the activation of critical and higher order thinking. Though it is an important goal of education, it is still challenging for teachers to activate and cultivate pupils' critical thinking. According to research conducted all throughout the world, critical thinking skills of most students are poor to some extent. [1]. Critical thinking occurs when students are inferring, self-regulating, explaining, and interpreting creative thought to solve a problem, make a judgement or reach a conclusion. These skills are needed to be developed among the students to become good critical thinkers.

Critical thinking is an important component of 21st-century learning. The spoon-feeding system in education has improved. It is a better schooling era. The most important purpose of education is to foster critical thinking in students, not to make them mimic others. It is crucial to foster critical thinking skills in students through education. Accordingly, this study will investigate the effect of interactive and indirect instruction in developing the critical thinking skills of grade 10 in a flipped science classroom.

MATERIALS AND METHODS

The study employed a quasi-experimental research design to determine whether interactive and indirect instruction develops critical thinking skills in grade 10 in a flipped science classroom. Quasi-experiments are studies that try to evaluate interventions but do not involve randomization. Furthermore, it seeks to illustrate the relationship between an intervention and an outcome. Furthermore, quasi-experimental studies can include both pre- and post-intervention assessments, as well as non-randomly selected control groups.

The respondents of the study were the two sections of Grade ten learners of Sta. Anastacia – San Rafael National Highschool in the Division of Sto. Tomas City in Sto. Tomas Batangas during the academic year 2022-2023. They are comparable groups consisting of 50 students in each section under the teaching supervision of the researcher as a science 10 teacher.

The study utilized instruments to gather the data needed to answer the research problems. This includes a pre–post test about critical thinking skills. The researcher-made pre and post-test composed of forty (40) item multiple-choice and essay questions based on the competencies in the third quarter of science 10, assessed the respondents' critical thinking skills before and after the implementation of the flipped teaching strategy in terms of inference, self-regulation, explanation, and interpretation. These instruments were validated by two master teachers, language experts, and a research coordinator and they went through pilot testing and reliability test. The reliability test performed on the assessment of the critical thinking skills of the respondents revealed that in terms of inference, self-regulation, explanation, and interpretation had an internal consistency of 0.795, 0.933, 0.911, and 0.937 respectively, and interpreted as "acceptable".

Lesson exemplars utilized in this study were based on the flipped teaching strategies It adhered to the Department of Education's design framework, which was based on the PIVOT I-D-E-A (Introduction, Development, Engagement, and Assimilation) Lesson Exemplar. It includes the Most Essential Learning Competencies (MELC) in the third grading period of Science 10. The materials were checked and validated by a language evaluator.

The collected data was subjected to different statistical measurements and methods to help the researcher in presenting, analyzing, and interpreting the data. The pre-post test scores of the of the respondents of the study were described using mean, SD, frequency count, and percentage. The independent samples t-test was used to compare the means of two groups of respondents, and the paired t-test was used to see if there were any significant differences in the pre-test and post-test scores of

respondents who received interactive and indirect instruction.

RESULTS AND DISCUSSION

Table 1 Pre-test Score of the Respondents Exposed to Flipped Teaching Strategies as to Inference

Scores	Interactive		Indirect		Interpretation
	Frequency	Percent	Frequency	Percent	
9-10	--	--	--	--	Excellent
7-8	1	2	--	--	Very Good
5-6	12	24	15	30	Good
3-4	29	58	29	58	Average
0-2	8	16	6	12	Poor
Total	50	100	50	100	

Table 1 illustrates the pre-test scores of the two groups of respondents exposed to flipped teaching strategies as to inference. At the onset of instruction during the pre-test, only two percent (2%) of the respondents exposed to interactive instruction got a score of 7-8 and nobody in indirect instruction got a very good level. Hence, both groups of respondents got the average level, and it implies that both groups are on the same level of understanding before instruction. Since this is just a pre-test, the respondents' scores are mostly close to the poor level. This implies that students from both groups of instruction make inferences with limited clarity using ideas from information, personal knowledge, and experiences. Students use finite background knowledge and details from the information to draw inferences.

One of the major skills required for comprehension is inference. According to [2], good comprehension requires inference; inference is a "foundational skill." According to [3], one of the components of critical thinking is inference. According to him, inference is the ability to detect and derive plausible conclusions, to form conjectures and hypotheses, and to consider relevant data. Inference sub-skills include speculating on possibilities and reaching conclusions. According to [4], children with low reading comprehension abilities were less able to infer the meanings of novel vocabulary items from context than their skilled counterparts. The close proximity of the novel word and the relevant context influenced the performance of the less skilled group.

Table 2 Pre-test Score of the Respondents Exposed to Flipped Teaching Strategies as to Self-regulation

Scores	Interactive		Indirect		Interpretation
	Frequency	Percent	Frequency	Percent	
9-10	--	--	--	--	Excellent
7-8	3	6	7	14	Very Good
5-6	20	40	13	26	Good
3-4	18	36	12	24	Average
0-2	9	18	18	36	Poor
Total	50	100	50	100	

Table 2 illustrates the pre-test scores of the respondents exposed to flipped teaching strategies for self-regulation. Before the pre-test scores of the respondents from interactive instruction forty percent (40%) of the respondents attained a good level and six percent (6%) attained a very good level. Meanwhile, thirty-six percent (36%) of the respondents from the indirect instruction are on the average level and fourteen percent (14%) are on the very good level. It is indicated that students from indirect instruction are moderately good before instruction. Based on the pre-test scores of the students, it implies that most of the students from the interactive group at least can reflect and question their own's thinking and have the self-awareness that consciously recognizes their thoughts while students from indirect instruction are somewhat expressed a thoughtful personal reflection and point of view.

The study of [5] reported that the use of self-regulation is the lower degree of critical thinking. Additionally, it showed that the pupils' capacity to sharpen their critical-thinking abilities was lacking. Self-regulation is the capacity to manage one's own thought processes and undo mistakes that have been committed. This means that checking one's own comprehension requires the use of critical thinking abilities [3]. According to the research done by [6], the group investigation integrated with think talk write learning approach led to an improvement in the students' self-regulation abilities. These findings demonstrate how well the group investigation combined with the think-talk-write technique works to help students develop their self-control or self-regulation skills. The students' self-regulation skills data collected using an inventory before and after the group investigation, which was combined with the think talk learning technique.

Table 3 Pre-test Score of the Respondents Exposed to Flipped Teaching Strategies as to Explanation

Scores	Interactive		Indirect		Interpretation
	Frequency	Percent	Frequency	Percent	
9-10	--	--	--	--	Excellent
7-8	--	--	1	2	Very Good
5-6	3	6	4	8	Good
3-4	28	56	21	42	Average
0-2	19	38	24	48	Poor
Total	50	100	50	100	

Table 3 illustrates the pre-test scores of the respondents exposed to flipped teaching strategies as to the explanation. Based on the pre-test scores of the students from interactive instruction, fifty-six percent (56%) attained the average level and six percent (6%) attained the good level. This implies that the students are moderately good at expressing the result of reasoning. On the other hand, students from indirect instruction forty-eight percent (48%) attained the lowest level of score or the poor level and only two percent (2%) attained a very good level which in it indicates that students from this group have less prior knowledge of the lesson. Based on the result of the pre-test scores of the respondents, most of the students from the interactive group and indirect instruction were not yet able to explain, express, and reason out the information.

Explanation as a skill refers to the capacity to present the outcomes of one's reasoning in a persuasive and articulate manner. This entails not only being able to restate knowledge, but also adding

clarity and perspective to it so that it may be properly understood by anyone with whom you share it. According to [7] study, students' scientific explanation was improved by integrated physics learning with e-scaffolding. Improvements were made in claim, evidence, and reasoning—all components of scientific explanation. The claim aspect experienced the greatest improvement. These two elements—claim and evidence—have greatly expanded as a result of cooperative problem-solving activities. The sub-skills under "explanation" include "description of methods and results, justification of procedures, proposal and defense of one's fundamental and conceptual explanations with justification of events or points of view.

Table 4 Pre-test Score of the Respondents Exposed to Flipped Teaching Strategies as to Interpretation

Scores	Interactive		Indirect		Interpretation
	Frequency	Percent	Frequency	Percent	
9-10	3	6	1	2	Excellent
7-8	5	10	4	8	Very Good
5-6	22	44	18	36	Good
3-4	7	14	12	24	Average
0-2	13	26	15	30	Poor
Total	50	100	50	100	

Table 4 illustrates the pre-test scores of the respondents exposed to flipped teaching strategies as to interpretation. On the pre-test scores of the two groups exposed to flipped teaching strategies as to the interpretation, both groups got the highest percentage in the average level. However, six percent (6%) of students from interactive instruction and two percent (2%) of students from indirect instruction attained an excellent level. Therefore, based on the pre-test scores of the students, it implies that most of the students have no prior knowledge of the lesson while some can interpret and make meaningful connections of concepts.

Interpretation, according to [8], is the ability to understand and comprehend the information being provided, as well as communicate the meaning of that information to others. Subskills in interpretation include categorization, decoding significance, and clarifying meaning. In order to grasp, one must relate new knowledge to what one already knows. The more one engages with the material, the more one understands it. The major indicator of comprehension is the ability to put what one has read or heard into one's own words.

Table 5 Post test Score of the Respondents Exposed to Flipped Teaching Strategies as to Inference

Scores	Interactive		Indirect		Interpretation
	Frequency	Percent	Frequency	Percent	
9-10	2	4	1	2	Excellent
7-8	28	56	11	22	Very Good
5-6	17	34	38	76	Good
3-4	3	6	--	--	Average
0-2	--	--	--	--	Poor
Total	50	100	50	100	

Table 5 illustrates the post-test scores of the respondents exposed to flipped teaching strategies as to inference. After using the flipped teaching strategies, four percent (4%) of the respondents exposed to interactive instruction and two percent (2%) of the respondents exposed to indirect instruction attained an excellent level. However, fifty-six percent (56%) of respondents from interactive instruction attained a very good level and seventy-six percent (76%) or a majority of the respondents exposed to indirect instruction attained a good level. The result of the post-test implies that the majority of the students from both groups of instruction are very good at inference. When the student is good at inferencing, students learned, know, and can identify, and make conclusions about the topic. The students improve their inference skills such as drawing conclusions and using ideas from information, personal knowledge, and

experiences to draw inferences through the different activities involved in the flipped teaching strategies such as collaborative activities, cooperative learning, laboratory groups, concept formation, and concept mapping.

According to [5], the majority of pupils used inference skills in their reading. Inference is also listed as a critical thinking component by [3]. Inference, according to him, is the ability to detect and draw plausible conclusions, to create conjectures and hypotheses, and to consider pertinent facts. Conjecturing alternatives and making conclusions are sub-skills of inference. According to a study conducted by [9], Children took longer to respond with a yes or no in the probe verification task when they had to base their choice on a situation model representation of the scenario (in the inference condition), but not when they could base their choice on a text-based representation (in the control condition).

Table 6 Post test Score of the Respondents Exposed to Flipped Teaching Strategies as to Self-regulation

Scores	Interactive		Indirect		Interpretation
	Frequency	Percent	Frequency	Percent	
9-10	5	10	6	12	Excellent
7-8	25	50	21	42	Very Good
5-6	18	36	19	38	Good
3-4	2	4	4	8	Average
0-2	--	--	--	--	Poor
Total	50	100	50	100	

Table 6 illustrates the post-test scores of the respondents exposed to flipped teaching strategies for self-regulation. The post-test scores of the two groups of respondents exposed to flipped teaching strategies as to self-regulation indicate that both groups got the highest percentage score of fifty percent (50%) from the interactive instruction and seventy percent (70%) in the indirect instruction of very good level. Hence, four percent (4%) from interactive instruction and two percent (2%) from indirect instruction attained the average level. From this, after the flipped teaching strategies, the students improved their self-regulation skills. From the result of the post-test scores, the majority of the students from both groups of instruction improved their self-regulation skills through their own's thinking or self-reflection on interpretation and judgment.

[10] argues that self-regulation means self-consciously monitoring how well someone seems to understand or comprehend what they are reading or experiencing. Similarly, self-regulation entails rethinking our own interpretation or judgment based on more factual analysis. Self-correction is an aspect of self-regulation. One of the components demonstrating critical thinking skills is the students' ability to self-regulate. As a result, the students' medium level of self-regulation is an early indication that this basic ability should be developed in order to improve students' critical thinking skills.

Table 7 Post test Score of the Respondents Exposed to Flipped Teaching Strategies as to Explanation

Scores	Interactive		Indirect		Interpretation
	Frequency	Percent	Frequency	Percent	
9-10	--	--	--	--	Excellent
7-8	20	40	6	12	Very Good
5-6	29	58	43	86	Good
3-4	1	2	1	2	Average
0-2	--	--	--	--	Poor
Total	50	100	50	100	

Table 7 illustrates the post-test scores of the respondents exposed to flipped teaching strategies as to the explanation. After using the flipped teaching strategies, fifty-eight percent (58%) of respondents

from interactive instruction and eighty-six percent (86%) of respondents from indirect instruction attained a good level. Hence, there is still two percent (2%) of the respondents from interactive and indirect instruction who attained the average level. It is indicated that from both groups of respondents, the majority are on the good level where learners can explain the ideas thus, it implies that both sets of respondents' explanation skills, such as reasoning and justification, enhanced. Students who received interactive and indirect instruction thoroughly clarified topics and were able to express their thinking using conceptual and contextual evidence.

Explanation is the ability to inform the process of thinking or to inform the conclusion to others. According to [5], more than half of the students employed explanation skills in reading at least once. According to [11], someone with explanation talent will have a powerful and coherent style of presenting the outcome of their reasoning. He goes on to say that this is one of the critical thinking components. As sub-skills of explanation, it comprises discussing techniques and findings, justifying procedures, and delivering thorough and well-reasoned explanations.

Table 8 Post test Score of the Respondents Exposed to Flipped Teaching Strategies as to Interpretation

Scores	Interactive		Indirect		Interpretation
	Frequency	Percent	Frequency	Percent	
9-10	22	44	12	24	Excellent
7-8	26	52	27	54	Very Good
5-6	1	2	11	22	Good
3-4	1	2	--	--	Average
0-2	--	--	--	--	Poor
Total	50	100	50	100	

Table 8 illustrates the post-test scores of the respondents exposed to flipped teaching strategies as to interpretation. After being exposed to flipped teaching strategies the data above revealed that fifty-two percent (52%) of the respondents in interactive instruction and fifty-four percent (54%) of the respondents under indirect instruction attained the level of very good. In addition, forty-four percent (44%) of the respondents from interactive instruction and twenty-four (24%) from indirect instruction attained an excellent level. Moreover, this implies that their scores improve upon exposure to different flipped teaching strategies. Students from the interactive and indirect instruction can clearly state the reason and can fully identify meaningful connections. It connotes that the learners exposed to both instructions learned and enhanced their interpretation skills by comprehending and expressing the meaning or significance of images, concepts, and data.

[11] lists interpretation as another aspect of critical thinking. Understanding information is the ability to interpret it [8]. Additionally, [11] notes that understanding and conveying the meaning of a range of experiences, circumstances, data, events, judgments, norms, beliefs, rules, procedures, or criteria are all regarded to be parts of interpretation. The sub-skills of classification, significance decoding, recognition, and meaning clarification are all parts of interpretation. This reading ability includes things like recognizing the text type, summarizing the primary concept, and determining the author's intent, theme, or point of view.

Table 9 Significant Difference of Pre-test Score of the Respondents Exposed to Flipped Teaching Strategies

Critical Thinking Skills	Interactive		Indirect		t	df	Sig. (2-tailed)	95 % Confidence Interval of the Difference	
	Mean	SD	Mean	SD				Lower	Upper
Inference	3.76	1.22	3.80	1.12	-.170	98	.865	-.506	.426
Self-regulation	4.18	1.56	4.02	1.86	.466	98	.642	-.521	.841
Explanation	2.98	0.98	2.96	1.16	.093	98	.926	-.406	.446
Interpretation	4.60	2.19	4.18	1.86	1.033	98	.304	-.387	1.227

Legend: Sig. (2-tailed) ≤ .05 (significant); Sig. (2-tailed) >.05 (not significant)

Table 9 illustrates the summary of values for the test of difference on the pre-test scores of the two groups of respondents exposed to interactive instruction. The data revealed that there is no significant difference in the pre-test scores of the respondents exposed to flipped teaching strategies. This further means that the level of understanding of the students from flipped teaching strategies before the instruction does not differ. It implies that students from both groups of instruction can make quite inferences, express somewhat thoughtful personal reflection and point of view, explain minor concepts, and analyze and discover some relevant links between concepts and ideas before instruction.

Inference is the ability of drawing conclusions based on relevant data, information, and personal knowledge and experiences. Although both groups are not yet exposed to instruction, students from the indirect instruction are shown to have more prior knowledge about the lesson than the students from the interactive instruction. Prior to instruction, students from the indirect instruction have more skills of drawing conclusions, developing ideas and ability to guess and predict using clues. Prior knowledge has a part in inferencing, according to [12]. Inferences require prior information, which is a crucial precondition. According to Cain et al. [4], its ability to encourage the development of inferences is only partially effective. It would seem to largely help children who already know a lot and are good at incorporating new knowledge into the networks of their existing schemata. But it's uncertain whether attempting to activate prior knowledge is worthwhile.

Self-regulation refers to the continuous monitoring, questioning one's own thinking and reflecting on interpretation and judgment. Before the instruction, students from the interactive instruction shown to have more prior knowledge of the lesson and have more skills of examining self, questioning, and recognizing self in thinking than the students from the indirect instruction. Prior to instruction, interactive group can self-critique and evaluate own judgement.

According to [13], self-regulation is "the self-directed process by which learners transform their mental abilities into task related skills." It is the strategy used by students to organize and control their thoughts in order to develop learning-related skills. Self-regulation, according to Berk (2003), is the process of periodically monitoring progress toward a goal, assessing results, and refocusing fruitless efforts. To be able to self-regulate, students need to be inspired to actively participate in their own learning [13]. Additionally, they must be conscious of their own cognitive processes.

Explanation is the presentation of one's reasoning in the form of coherent arguments after stating the outcomes of one's thinking; justifying that reasoning in terms of the evidentiary, conceptual, methodological, criteriological, and contextual considerations upon which one's results were based. Although both groups are not yet exposed to instruction, students from the interactive instruction are shown to have more prior knowledge about the lesson than the students from the indirect instruction. Prior to instruction, students from interactive instruction had improved their ability to state outcomes, defend techniques, and offer arguments.

[14] discovered that explanation-seeking pedagogies, as opposed to fact-seeking pedagogies, result in improved student understanding. It has been demonstrated that explanation-driven teaching methods are more effective in helping students enhance their comprehension skills than fact-driven ones. In spite of scoring much lower than less engaged students in the pre-activity interviews, the study found that students with the greatest written explanations on Knowledge Forum performed significantly better on the post-activity interviews. Prior to instruction, students who participated in interactive education had

better results-stating, procedure-justification, and argument-presenting abilities.

Interpretation is to understand and express the meaning or significance of a wide range of experiences, circumstances, data, events, judgments, norms, beliefs, rules, procedures or criteria. Before the instruction, students from the interactive instruction shown to have more prior knowledge of the lesson and have better categorization, decoding significance, and clarification skills than kids who received indirect instruction.

Based on a study conducted by [15]. The average class grade served as a 2021 interpretive indicator of critical thinking abilities. Students were required to comprehend and articulate the meanings of numerous situations, data, experiences, events, judgments, beliefs, rules, processes, and criteria as an evidence of their ability to interpret. Some pupils were able to determine a word's definition from the research that was used in the reading. However, the majority of pupils were unable to determine the word's definition. Many of them gave answers that either (a) mentioned meaning only briefly without more explanation, (b) summarized the question and gave it as an answer, or (c) provided an ad hoc response.

In the study by [16], there was no sinificant difference between the two instructional modes when comparing the teaching strategies of lectures and group discussions for cultivating critical thinking skills. However, from the pretest to the posttest, both teaching modalities shown considerable improvements. Particularly in terms of total score, low level thinking items, and high level thinking items, lectures produced significant learning. However, group discussions significantly increased learning when it came to more advanced subjects. These findings imply that in-person instruction has a significant effect on students' learning.

Table 10 Significant Difference of Pre-test and Post test Score of the Respondents Exposed to Flipped Teaching Strategies as to Interactive Instruction

Critical Thinking Skills	Pre-test		Post-test		t	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
	Mean	SD	Mean	SD				Lower	Upper
Inference	3.76	1.22	6.70	1.27	-16.187	49	.000	-3.305	-2.575
Self-regulation	4.18	1.56	6.80	1.32	-12.983	49	.000	-3.026	-2.214
Explanation	2.98	0.98	6.28	1.14	-16.983	49	.000	-3.690	-2.910
Interpretation	4.60	2.19	8.42	1.14	-13.597	49	.000	-4.385	-3.255

Legend: Sig. (2-tailed) ≤ .05 (significant); Sig. (2-tailed) >.05 (not significant)

Table 10 illustrates the summary of values for the test of difference on the pre-test and post-test scores of the two groups of respondents exposed to interactive instruction. The table reveals that there is a significant difference between the pre-test and post-test scores of the respondents as they are exposed to flipped teaching strategies in terms of interactive instruction. The result shows that the students improve critical thinking skills in flipped teaching strategies as to interactive instruction. Interactive instruction opens the path to the students learning. Students can draw conclusions, draw inferences, can reflect on their own's thinking, can reason out, and interpret concepts and ideas. Students also understand the science concepts and the application of critical thinking skills. This implies that the interactive instruction utilized a hands-on approach that helps students understand and learn the subject matter from peers and teachers that develop their critical thinking skills through an inquiry process that analyzes data to produce unique and creative ways for making informed decisions, evaluations, and organize their thoughts. It connotes that interactive instruction is an effective flipped teaching strategy in developing the critical thinking skills of the students.

The trend in education where students actively participate in lessons rather than being passive users of knowledge is referred to as interactive instruction. This hands-on approach to education can help students engage with the course material, stay focused, and learn more as they interact with the subject, the instructor, and one another. This teaching technique is diametrically opposed to the traditional classroom, in which a teacher stands at a board or projector and lectures while pupils passively take notes. This interactive learning technique suits students with diverse learning styles. The purpose of interactive learning is to promote student learning by involving them in the actual learning process. The strategies

that can most effectively assist them with that goal should be pursued.

Flipped teaching strategies pave the way to the student's learning. Different activities from the interactive instruction help and provide students by applying concepts and communicating new knowledge, students learn through participating in knowledge acquisition by gathering information and processing it by communicating what they have learnt. By receiving information, digesting it, and then articulating what they have learned, students learn by actively participating in the pursuit of knowledge. Additionally, students are able to apply fundamental critical thinking techniques and comprehend scientific topics. This implies that interactive instruction makes the learning experience engaging and meaningful. It connotes that interactive instruction is effective in developing core critical thinking skills of the students.

According to the study of [17], inquiry-based learning in foreign language learning classroom empowers students' critical thinking skills. Inquiry-based learning has positive impacts on students' critical thinking skills which include interpretation, analysis, inference, evaluation, explanation, and self-regulation. In other words, when students received inquiry-based learning instruction in classes, they understood and presented their thoughts.

Table 11 Significant Difference of Pre-test and Post test Score of the Respondents Exposed to Flipped Teaching Strategies as to Indirect Instruction

Critical Thinking Skills	Pre-test		Post-test		t	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
	Mean	SD	Mean	SD				Lower	Upper
Inference	3.80	1.12	6.00	1.05	-11.353	49	.000	-2.589	-1.811
Self-regulation	4.02	1.86	6.68	1.43	-13.218	49	.000	-3.064	-2.256
Explanation	2.96	1.16	5.60	0.78	-18.569	49	.000	-2.926	-2.354
Interpretation	4.18	1.86	7.56	1.55	-12.274	49	.000	-3.933	-2.827

Legend: Sig. (2-tailed) ≤ .05 (significant); Sig. (2-tailed) >.05 (not significant)

Table 11 illustrates the summary of values for the test of difference on the pre-test and post-test scores of the two groups of respondents exposed to indirect instruction. The table reveals that there is a significant difference between the pre-test and post-test scores of the respondents as they were exposed to flipped teaching strategies in terms of indirect instruction. The result shows that the students improve critical thinking skills in the flipped science classrooms as to indirect instruction. Indirect instruction paves the way for the student's learning. Students from interactive instruction can make inferences, can reflect on their own's thinking, can reason out, and interpret concepts and ideas. Students also understand the science concepts and the application of critical thinking skills. This suggests that the indirect instruction involved a higher level of student involvement and included activities like observation and investigation that encourage creativity, the development of interpersonal skills, and the application of critical thinking skills through an inquiry process that engaged the learner's curiosity in what the learner has to learn by observing, investigating, and drawing conclusions from data. It implies that using indirect instruction is a successful flipped teaching technique for helping students build their critical thinking abilities.

Indirect instruction is a student-centered learning style in which students observe, examine, and make conclusions from the evidence. Instead of providing direct instruction, academics play the role of facilitator or supporter in this educational paradigm. It is the incorporation of inquiry, problem-solving, and decision-making into the learning process that is referred to as indirect instruction. When tackling difficulties, this strategy requires higher-order thinking. Students can build meaningful connections to course content by relying on their own experiences.

Activities from indirect instruction provide flexibility for the students to explore diverse learning activities, foster creativity, and development of interpersonal skills. Students understand and integrate science concepts and the application of critical thinking skills. This implies that indirect instruction makes the learning experience engaging and meaningful. It connotes that indirect instruction is effective in developing the critical thinking skills of the students.

Based on the study of [18] students who had received strategy education displayed critical thinking more effectively than those who had not. The findings showed that professors agree that developing students' critical thinking abilities increases the course's educational value. Teachers firmly believe that pupils should be encouraged to practice critical thinking as a habit.

Table 12 Significant Difference of Post test Score of the Respondents Exposed to Flipped Teaching Strategies

Critical Thinking Skills	Interactive		Indirect		t	df	Sig. (2-tailed)	95% Confidence Interval of the Difference	
	Mean	SD	Mean	SD				Lower	Upper
Inference	6.70	1.27	6.00	1.05	3.010	98	.003	.239	1.161
Self-regulation	6.80	1.32	6.68	1.43	.434	98	.665	-.428	.668
Explanation	6.28	1.14	5.60	0.78	3.470	98	.001	.291	1.069
Interpretation	8.42	1.14	7.56	1.55	3.151	98	.002	.318	1.402

Legend: Sig. (2-tailed) ≤ .05 (significant); Sig. (2-tailed) >.05 (not significant)

Table 12 illustrates the summary of values for the test of difference on the post-test scores of the two groups of respondents exposed to interactive instruction. The data revealed that different variables of critical thinking skills like inference, explanation, and interpretation show a significant difference in terms of the respondents post-test scores as to different flipped teaching strategies. Meanwhile, self–regulation shows no significant difference in terms of their post-test scores for interactive and indirect instruction. This further means that the level of understanding of the students from flipped teaching strategies as to inference, explanation, and interpretation after the instruction differ except for the self-regulation. Based on the findings, as the students improve their critical thinking skills in terms of inference, explanation, and interpretation, they inversely perceived the effectiveness of the flipped teaching strategies as to self-regulation. It can be inferred that students from both groups of instruction can infer and draw conclusions based on relevant data, information, and personal knowledge and experiences, comprehensively explain ideas, clearly describe reasoning, and fully recognize meaningful links between ideas and concepts.

Inference is the ability of forming judgments based on pertinent data, information, and personal experiences. Although both groups of respondents learned, the interactive group learned and benefited more through their participation and collaboration with their peers. Based on the activities of the students in the interactive instruction such as puzzles, research, project making and peer learning activities, students are responsible for constructing and demonstrating knowledge because of the collaboration with peers to create knowledge and draw conclusions. This implies that students' participation in class activities is essential for effective learning.

According to [19] students can derive conclusions from arguments and supporting facts by using inference abilities. When making thoughtful recommendations and hypotheses, inference is used. A given combination of facts and circumstances will result in certain consequences, which are either required or extremely likely. Even when applying great inference techniques, conclusions, hypotheses, judgements, or recommendations that are based on flawed analyses, false information, flawed data, or biased evaluations may out to be incorrect.

Explanation pertains to skill required to express the result of a person’s reasoning supported by conceptual and contextual evidence. Based on the instructions, both groups learned however, it is also indicated that students from the interactive instruction group learned more because the activities involving in the instruction such as comparison charts, model making and song composition which allows the group to construct new knowledge, share their ideas and explain the concept with their peers. Students from the interactive instruction are given more time to interact with their classmates because they work in pairs or groups.

According to [20] students can learn topics by applying their expertise. The students then engage in group discussions and observations to support the prediction and identify a problem-solving strategy. Additionally, this is consistent with the study of [21], the predict-observe-explain method can aid students in comprehending a subject through direct observation, and the action of observation serves as an explanation or solution to a given issue.

Interpretation refers to categorizing and making meaningful connections of concepts, experiences, situations, data, events, judgments, beliefs, rules, procedures, or criteria. After the flipped teaching strategies, both groups learned. Students from the interactive instruction learned more from the activities because they can easily interpret situations, pictures, and procedures because of the interactive activities such as identifying the parts of the reproductive, endocrine and nervous system through images. In an interactive classroom with interactive tools and gadgets, students are actively involved in the learning process.

Inferring, or drawing a judgment after studying data, is closely related to interpreting. In one sense, interpreting involves inferring. By definition, according to Singh (2022), interpretation abilities are the capacity of a person to correctly uncover, determine, and infer the appropriate meaning of the information. Students read textbooks and information from resources; they appropriately understand the knowledge to write it down for assessments. And based on the study of [5] majority of the students used interpretation skills in reading comprehension.

According to [22], the method of science learning emphasizes providing students with direct experience in order to increase their competency. Teachers must be creative and imaginative in order to increase pupils' critical thinking skills. According to the study, there are substantial differences in the average value of the post test of students' critical thinking skills after the intervention between the experimental and control classes. As a result, incorporating guided inquiry using number heads into the learning process might increase students' critical thinking skills.

CONCLUSION

The primary aim of this study was to determine the effectiveness of interactive and indirect instruction in developing critical thinking skills among Grade 10 students in a flipped science classroom. Additionally, it examined any significant difference in the pre-test and post-test scores of the respondents exposed to flipped teaching strategies in the critical thinking skills test.

The results revealed that four variables of critical thinking skills showed no significant difference in terms of the pre-test scores of the respondents exposed to flipped teaching strategies supported by evidence. Moreover, there is a significant difference between the pre-test and post-test scores of the respondents in the critical thinking skills as they are exposed to flipped teaching strategies specifically interactive and indirect instruction. The study also revealed that there is a significant difference in the post-test scores of the respondents exposed to flipped teaching strategies in terms of inference, explanation, and interpretation after the implementation of the different flipped teaching strategies except for self-regulation.

This study suggests that educators may use flipped teaching strategies as an approach to teaching science lessons to improve students’ performance and critical thinking. Teachers may foster critical thinking skills in lessons to help learners understand science concepts. Learners must develop the critical thinking skills required to think critically in increasingly innovative ways. It is also recommended that future researchers may use interactive and indirect instruction, as well as different instructions or strategies on other subject areas that can be incorporated into the teaching-learning process to strengthen students' critical thinking skills.

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