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Examining the Nexus of Scientific Reasoning and Critical Thinking in Higher Secondary School Students

Simi M.
Research Scholar, Department of Education, University of Kerala
E-mail: simimphd2019@gmail.com

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Research Paper

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ABSTRACT

The development of critical thinking skills has long been recognized as a crucial element in the holistic education of students, particularly at the higher secondary level. This study aims to explore the relationship between scientific reasoning and critical thinking abilities among higher secondary students. Fostering a strong foundation in scientific reasoning and critical thinking is essential for students to navigate the complexities of the modern world, make informed decisions, and tackle multifaceted problems effectively. (Salirawati et al., 2021).This study explores the relationship between scientific reasoning and critical thinking among higher secondary students. By investigating how these cognitive skills interact, the research aims to provide insights into their combined impact on students' academic performance.The study employs a quantitative research design with a sample of 200 higher secondary students from diverse educational backgrounds. The findings reveal a significant correlation between scientific reasoning and critical thinking, suggesting that these skills are mutually reinforcing and crucial for academic success. The study's implications for educational practice and curriculum design are discussed.

Introduction: The ability to reason scientifically and think critically is essential for students, especially in higher secondary education, where they are expected to engage with complex and abstract concepts.

Scientific reasoning involves the ability to apply the scientific method to solve problems, while critical thinking encompasses the ability to evaluate arguments, identify biases, and make informed decisions. Zulkipli et al. (2020) indicated that scientific reasoning strongly correlates with cognitive abilities as effective science reasoning involves logic, justification, rational thinking and decision making (Lei Bao et. al, 2009). Scientific reasoning, in general, is a type of reasoning that engages students in hypothesis development, particularly about how things work and then testing those hypotheses. During the reasoning process, individuals tend to associate the investigated phenomena with their prior knowledge and then new knowledge is sought after as the previous knowledge is corrected and integrated. According to Piaget's formal operational stage as cited by Steussy (1984), scientific reasoning is the use of scientific processing skills in order to justify a particular conclusion in scientific inquiry. This process includes the ability to relate the observed phenomena with scientific theory in order to predict possible outcomes. Scientific reasoning is employed within experimental design setting, hypothesis testing and data interpretation. Therefore, scientific reasoning comprises both conceptual understanding and inquiry skills (Zimmerman, 2005) in order to relate the experimental data with theories in producing the best conclusion. Undeniably, scientific reasoning is an important skill in science-related studies as it ensures effective implementation of experiments, hypothesis testing, data analysis and deduction of findings (Committee on Undergraduate Biology Education to Prepare Research Scientists (CUBE), 2003) cited in Schen (2007). According to Harefa (2024) The National Education Association (2015) highlights that 80% of executives believe a combination of the 4Cs enhances students' preparedness for the industry. Consequently, education strives to nurture critical thinking, collaboration, communication, and creativity in students, considering critical thinking as pivotal, especially in education. The National Association of Colleges and Employers (NACE) underscores critical thinking as the most crucial skill, given a significance level of 4.57 (98.5%) and a proficiency level of 3.68 (55.8%) compared to other competencies. This correlation supports the idea that student proficiency in career readiness improves through such competencies (Gray, 2021). Critical thinking, essential for analyzing and evaluating arguments effectively, often poses challenges for students in identifying logical fallacies, which can undermine an argument's credibility (Jones, 2018). This study aims to examine the nexus between these two cognitive skills to understand their combined impact on students' academic performance and overall cognitive development.

Need and Significance of the Study

Many educational systems struggle to foster these skills effectively, leading to gaps in students' understanding and abilities. Developing these skills empowers students to become informed citizens who can critically evaluate information and make evidence-based decisions. These skills equip students to make informed decisions in various aspects of their lives, from personal choices to societal issues. Identifying the strengths and weaknesses in these areas can help educators tailor their teaching methods to improve student outcomes. The study can shed light on the current state of scientific reasoning and critical thinking among higher secondary school students. This information can be used to address any deficiencies and build upon existing strengths. Findings from the study can contribute to the development of more effective educational policies and curricula that promote these essential skills. Educators can use the results to refine their teaching methods and create engaging learning experiences that foster scientific reasoning and critical thinking. A strong foundation in these skills is crucial for developing a scientifically literate population, which is essential for addressing global challenges. Scientific reasoning and critical thinking are essential tools for problem-solving, which is a valuable skill in various fields.

By examining the nexus of scientific reasoning and critical thinking in higher secondary school students, this study can provide valuable insights into the current state of these skills and offer recommendations for improvement. This can ultimately contribute to the development of well-rounded, informed, and critical thinkers. In the current era of rapid technological and scientific advancements, the need for robust critical thinking and scientific reasoning skills has become increasingly paramount (Loh, 2020) (Luzyawati et al., 2021) (Mishore & Abate, 2023). Students must be equipped with the necessary cognitive tools to analyze information, evaluate evidence, and make well-informed judgments. As such, understanding the interplay between scientific reasoning and critical thinking in the context of higher secondary education is crucial for designing effective pedagogical approaches and improving student outcomes. In toto, studying the nexus of scientific reasoning and critical thinking in higher secondary school students is essential for understanding the current state of these skills, developing effective teaching strategies, and promoting better learning outcomes. By addressing the identified needs and leveraging the significance of this research, educators can help students become more critical thinkers and informed citizens. The study can uncover the specific ways in which scientific reasoning and critical thinking are interconnected and influence each other. This understanding can inform instructional practices and curriculum design.By examining the development of these skills in higher secondary

school students, the study can provide insights into their strengths and weaknesses. This information can be used to tailor instruction and support students' learning.

The findings of the study can inform educational policies and practices at the school, district, and national levels. For example, it may lead to the development of new curriculum materials or professional development programs for teachers.This study can contribute to the existing body of research on scientific reasoning and critical thinking. By providing empirical evidence, it can help to validate or challenge existing theories and models. The study could investigate the role of teacher professional development in promoting the development of these skills in students. This might involve examining the effectiveness of specific professional development programs or identifying the challenges teachers face in implementing these strategies.

Research Questions

1. What is the relationship between scientific reasoning and critical thinking in higher secondary students?

2. What role do scientific reasoning and critical thinking play in students' academic performance?

Hypotheses formulated for the Study

H1: There is a significant positive correlation between scientific reasoning and critical thinking in higher secondary students.

H2: Higher levels of scientific reasoning lead to enhanced critical thinking abilities.

H3: Scientific reasoning and critical thinking significantly contribute to students' academic performance.

Objectives of the Study

1. To investigate the correlation between scientific reasoning and critical thinking in higher secondary students.

2. To assess the impact of scientific reasoning on critical thinking skills.

3. To evaluate the role of Scientific reasoning and critical thinking in students' academic performance.

Methodology in Brief

The study employs a quantitative research design to examine the relationship between scientific reasoning and critical thinking and their combined impact on students' academic performance.

Sample used for the Study

A sample of 200 higher secondary students was selected using stratified random sampling from various educational institutions. The sample included students from science, commerce, and humanities streams to ensure diversity.

Tools used for the Study

Scientific Reasoning Test (SRT): A standardized test measuring students' ability to apply the scientific method, analyze data, and draw logical conclusions.

Critical Thinking Assessment (CTA): A validated tool assessing students' ability to evaluate arguments, identify logical fallacies, and make reasoned decisions.

Data Collection

Data were collected through paper-based tests administered in a controlled classroom environment.

Statistical Analysis

1.Correlation

2.Multiple Regression

Analysis and Interpretation

Table 1:*Correlation of Scientific Reasoning and Academic Performance with Critical Thinking*

Variables	Correlation with CT (r)	p-value
Scientific Reasoning (SR)	0.65	<0.01
Critical Thinking (CT)	1.00	
Academic Performance (AP)	0.70	<0.01

From the table 1 ,it is clear that there is a significant positive correlation ($r = 0.65$, $p < 0.01$) between Scientific Reasoning and Critical Thinking,and a significant positive correlation ($r = 0.70$, $p < 0.01$) between Academic Performance and Critical Thinking, indicating that students who perform well in one area tend to excel in the other.

Figure 1

Correlation of Scientific Reasoning and Academic Performance with Critical Thinking

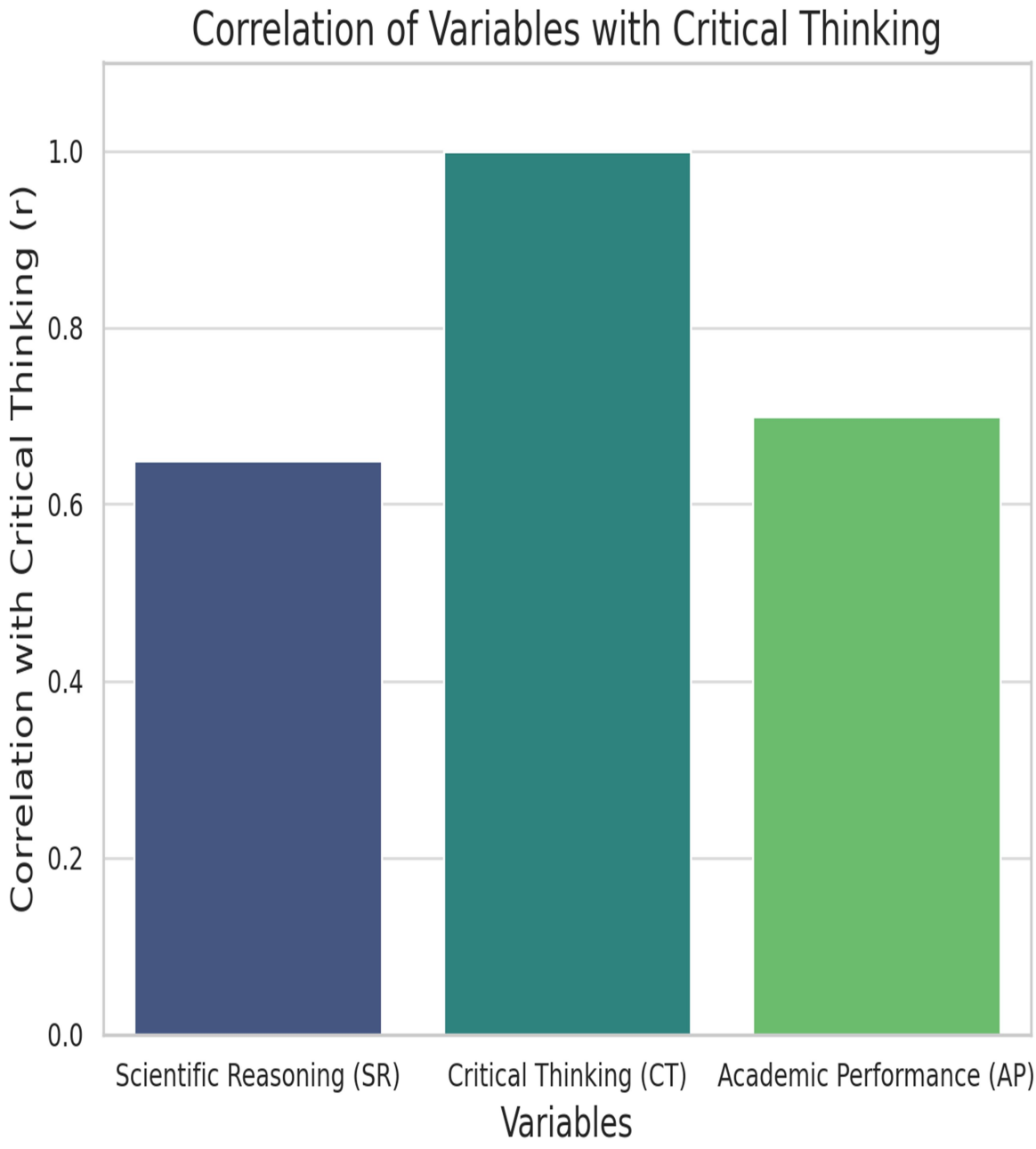

Figure 1 illustrates the strength of the relationships between the variables, Scientific Reasoning and Academic Performance and critical thinking.

Multiple Regression Analysis Summary

The multiple regression analysis was conducted to examine the impact of Scientific Reasoning (SR) and Critical Thinking (CT) on Academic Performance (AP).

Table 2

Impact of Scientific Reasoning (SR) and Critical Thinking (CT) on Academic Performance (AP).

Statistic	Value
R-squared	0.595
Adjusted R-squared	0.591
F-statistic	144.6
Prob (F-statistic)	2.22e-39
Number of Observations	200

Table 3

Variable	Coefficient (β)	Standard Error	t-value	p-value	95% Confidence Interval
Constant	33.5873	2.509	13.386	0.000	[28.639, 38.536]
Scientific Reasoning (SR)	0.3294	0.038	8.701	0.000	[0.255, 0.404]
Critical Thinking (CT)	0.4899	0.036	13.720	0.000	[0.419, 0.560]

Based on table 2 and 3 ,R-squared = 0.595: indicates that approximately 59.5% of the variance in Academic Performance (AP) can be explained by Scientific Reasoning (SR) and Critical Thinking (CT).Scientific Reasoning (SR) Coefficient (β = 0.3294): This suggests that for every one-unit increase in Scientific Reasoning, Academic Performance increases by approximately 0.33 units, holding Critical Thinking constant. Critical Thinking (CT) Coefficient (β = 0.4899): This suggests that for every one-unit increase in Critical Thinking, Academic Performance increases by approximately 0.49 units, holding Scientific Reasoning constant.Significance (p-values < 0.01): Both Scientific Reasoning and Critical Thinking are statistically significant predictors of Academic Performance.

Findings of the Study

- There is a significant positive correlation between Scientific Reasoning and Critical Thinking, indicating that students who perform well in one area tend to excel in the other.
- There is a significant positive correlation between Academic Performance and Critical Thinking, indicating that students who perform well in one area tend to excel in the other.
- Both Scientific Reasoning and Critical Thinking are statistically significant predictors of Academic Performance.

Implications of the Study

- The findings underscore the importance of integrating Scientific Reasoning and Critical Thinking into the higher secondary curriculum.
- Educators should focus on developing these skills through targeted instructional strategies, such as problem-based learning and inquiry-based science education.
- The study also highlights the need for curriculum designers to create interdisciplinary learning experiences that bridge the gap between Scientific Reasoning and Critical Thinking.
- The study's findings could inform curriculum development, emphasizing the integration of critical thinking skills into science education. This might involve incorporating activities that require students to evaluate evidence, analyze arguments, and draw conclusions based on scientific principles.
- The study could highlight the importance of STEM (Science, Technology, Engineering, and Mathematics) education in fostering both scientific reasoning and critical thinking. This would involve ensuring that STEM curricula are designed to promote these skills.

- The study could identify effective pedagogical approaches for teaching scientific reasoning and critical thinking. This might include strategies such as inquiry-based learning, problem-based learning, and cooperative learning.
- The study could inform the development of assessment tools that accurately measure students' abilities in scientific reasoning and critical thinking. This would help teachers identify areas where students need additional support.
- The study could provide evidence to support the inclusion of critical thinking skills in educational standards. This would ensure that students are equipped with the necessary skills for success in higher education and the workforce.
- The study could help justify the allocation of resources to support the development of scientific reasoning and critical thinking skills in schools. This might include funding for teacher training, curriculum development, and the purchase of instructional materials.
- By fostering scientific reasoning and critical thinking, the study could contribute to the development of students' problem-solving skills. This is essential for success in a rapidly changing and complex world.
- The study could highlight the importance of these skills for informed and engaged citizenship. Students who can evaluate information critically and make evidence-based decisions are better equipped to participate in democratic processes.

Conclusion

This study contributes to the understanding of the interplay between Scientific Reasoning and Critical Thinking in higher secondary education. The positive correlation between these skills highlights their mutual reinforcement and importance for academic success. The study's findings have significant implications for educators and curriculum developers aiming to enhance students' cognitive abilities and prepare them for the challenges of higher education and beyond. The multiple regression analysis confirms that both Scientific Reasoning and Critical Thinking significantly contribute to Academic Performance, with Critical Thinking having a slightly stronger influence. The model explains a substantial portion of the variance in Academic Performance, highlighting the importance of these cognitive skills in students' academic success.

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