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Scientific Reasoning and Problem Solving of Undergraduate Students: Gender and Academic Stream Wise Analysis

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ABSTRACT
Scientific knowledge, combined with strong reasoning skills, is the foundation of evidence-based problem solving. To help students succeed in science and the real world, educators need to understand how scientific thinking and problem solving abilities develop. This understanding allows for tailored instruction that improves student outcomes. Scientific reasoning has proven to be a major factor in problem solving success for students of all genders and academic backgrounds.The study intends to figure out the relationship between undergraduate students' use of scientific reasoning and their ability to solve problems, and it aims to assess that relationship in terms of gender and academic stream. A sample of 300 Undergraduate students from the Thiruvananthapuram district was selected for the present study. The stratified random sampling technique was employed for the present study, and the tools used were the Scientific Reasoning Assessment Test and Problem Solving Test. The result of the study shows that the Undergraduate students demonstrate moderate scientific reasoning and problem solving abilities. Importantly, the study found significant variations in these skills based on gender and academic

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focus. Furthermore, a strong positive correlation exists between scientific reasoning and problem solving within this student population.

Introduction

An enduring challenge in human cognition, children's learning, and education involves applying insights gained from initial learning situations to new, related problems (e.g., Barnett & Ceci, 2002; Detterman & Sternberg, 1993; Singley & Anderson, 1989; Thorndike & Woodworth, 1901). The main inquiries focus on the methods, timing, and degree to which individuals can access relevant information stored in long-term memory and apply past experiences to tackle similar situations (Chen & Klahr, 2008, pp. 419-470).One can argue more effectively and convincingly with greater credibility when he or she understand more about his or her subject. Apart from owning a solid understanding of the subjects and related topics and the cognitive capacity to identify interconnections between them, the person needs to have a strategic aptitude to identify how ideas, thoughts and knowledge gathered in certain area of the study can be applied to address concerns or advanced theories. ("How students develop scientific reasoning," 2016). So, scientific reasoning and problem solving are considered foundational skills that empower individuals to understand the world make informed decisions, and effectively address complex challenges.

Rational of the Study

Understanding how gender influences scientific reasoning and problem solving skills can provide insights into potential barriers or differences contributing to this gender gap. By examining scientific reasoning and problem solving skills across different academic streams, educators and curriculum developers can gain valuable insights into the effectiveness of current teaching methodologies and identify improvement areas. Tailoring educational approaches to better address the specific needs of students in different academic streams can enhance learning outcomes and student success. Proficiency in scientific reasoning and problem solving abilities is crucial for achieving success in diverse professional domains, especially those characterized by multidisciplinary approaches.Investigating how these skills vary based on academic stream can inform efforts to equip students with the knowledge and abilities essential for both their future professional success and achievements in their chosen field. Promoting diversity and inclusion within the discipline is critical for fostering innovation and addressing complex global challenges. Through comprehending the factors that impact the scientific reasoning and

problem solving abilities of undergraduate students, institutions can introduce specific interventions and support systems. This ensures that all students, irrespective of gender or academic background, have equitable opportunities to pursue and excel in diverse fields. Investigation in the realm of scientific reasoning and problem solving has the potential to enrich the wider pool of knowledge on cognitive development and educational psychology. Researchers can advance theoretical frameworks and generate new insights that inform future research and educational practice by investigating how these skills manifest in undergraduate students. To conclude, the study has the potential to yield valuable insights with practical implications for educational policy, curriculum development and efforts to promote diversity and inclusion of undergraduate students.

Research Questions

1. Does Undergraduate Students' Scientific Reasoning Affect Their Ability to Solve Problems?
2. Is there any significant difference between Undergraduate Students' Scientific Reasoning and Problem Solving with regard to gender?
3.Is there any significant difference between Undergraduate Students' Scientific Reasoning and Problem Solving with regard to academic streams?

Hypotheses formulated for the Study

1.The level of Scientific Reasoning of Undergraduate Students is moderate.
2.The level of Problem Solving of Undergraduate Students is moderate.
3. There exist significant difference in Scientific Reasoning of Undergraduate Students with regard to Gender.
4.There exist significant difference in Scientific Reasoning of Undergraduate Students with regard to Academic streams.
5.There exist significant difference in Problem Solving of Undergraduate Students with regard to Gender.
6.There exist significant difference in Problem Solving of Undergraduate Students with regard to Academic streams.
7.There is significant relationship between Scientific Reasoning and Problem Solving of Undergraduate Students.

Objectives of the Study

1.To find out the level of Scientific Reasoning of Undergraduate Students.

2.To find out the level of Problem Solving of Undergraduate Students.

3.To find out whether there is any significant difference in Scientific Reasoning of Undergraduate Students with regard to

1) Gender

2) Academic streams

4. To find out whether there is any significant difference in Problem Solving of Undergraduate Students with regard to

1) Gender

2) Academic streams

5. To find out whether there is any significant relationship between Scientific Reasoning and Problem Solving of Undergraduate Students.

Methodology in Brief

The investigator utilized a normative survey method for the investigation, focusing on the entire undergraduate student population in Kerala. A sample of 300 undergraduate students from the Thiruvananthapuram district was chosen using the stratified random sampling method. Tools used for the study were the Scientific Reasoning Assessment Test and Problem Solving Test. Scientific Reasoning Assessment Test with selected components like, Inductive reasoning, Deductive reasoning, Causal reasoning, Probabilistic reasoning and Correlational reasoning. Problem Solving test with selected components like, Identifying the problem, Analysing the problem and finding out effective solution were used for collecting data. The data gathered was analyzed using Descriptive Statistics, t-tests, and the Karl Pearson product-moment correlation coefficient.

Data Analysis and Interpretation

Analysis of the level of Scientific Reasoning of Undergraduate Students

The selected samples were classified into high, moderate, and low groups based on their Scientific Reasoning scores. The mean (M) and standard deviation (σ) of the selected 300 samples were found. Then M+ σ and M- σ were found. The students who scored above M+σ, i.e., score above 23.36, were included in high group. Students who scored M- σ, i.e., scores below 12.82, were included in the low

group, and students between 23.36 and 12.82 were included in the moderate group. The percentage of students belonging to each group was analysed, and Table 1 shows the analysis details.

Table 1

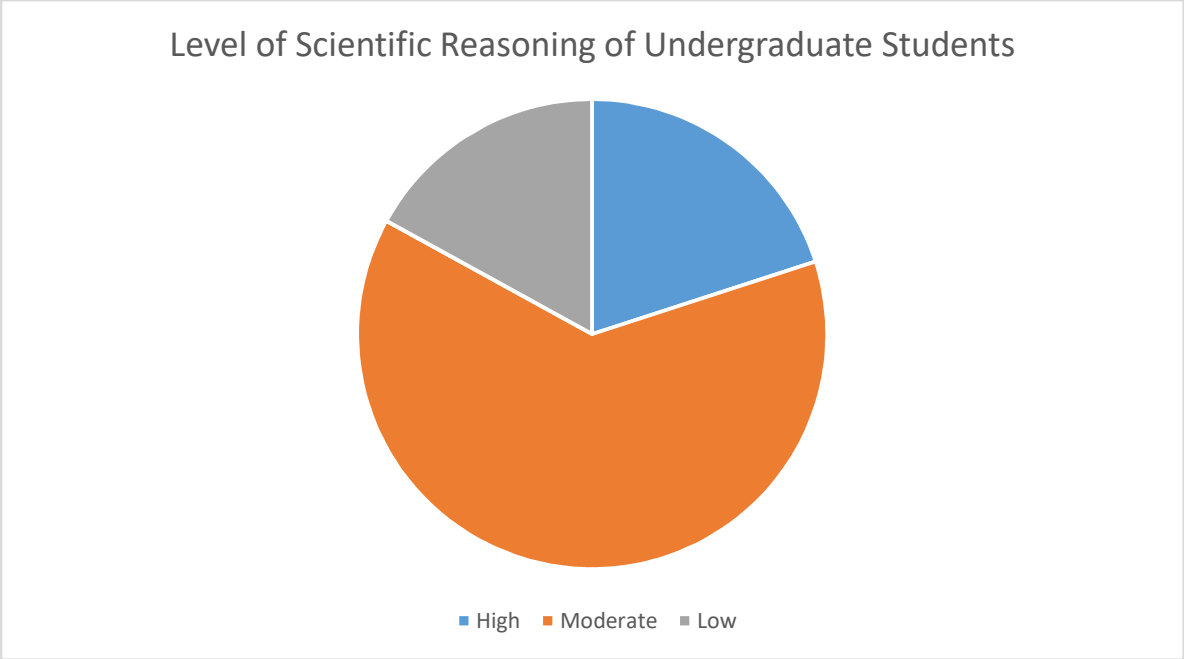
Level of Scientific Reasoning of Undergraduate Students

Variable	No. of Sample	Mean	Standard deviation	Level	Frequency	%
Scientific Reasoning	300	18.09	5.27	High	61	20.33%
				Moderate	188	62.67%
				Low	51	17%

From table 1, it is clear that 20.33% of undergraduate students out of the total sample belong to the high-level group of Scientific Reasoning, 62.67% of undergraduate students out of the total sample belong to the moderate level group of Scientific Reasoning, and 17 % of undergraduate students of the total sample belong to the low-level group of Scientific Reasoning. Hence the investigator concluded that undergraduate students have a moderate level of scientific reasoning.

Figure 1

Showing the level of Scientific Reasoning of Undergraduate Students



Analysis of the level of Problem Solving of Undergraduate Students

The selected samples were classified into high, moderate, and low groups based on their Problem Solving scores. The mean (M) and standard deviation (σ) of the selected 300 samples were found. Then M+ σ and M- σ were found. The students who scored above M+σ, i.e., score above 22.45, were included in high group. Students who scored M- σ, i.e., scores below 14.19, were included in the low group, and students between 22.45 and 14.19 were included in the moderate group. The percentage of students belonging to each group was analysed, and table 2 shows the analysis details.

Table 2

Level of Problem Solving of Undergraduate Students

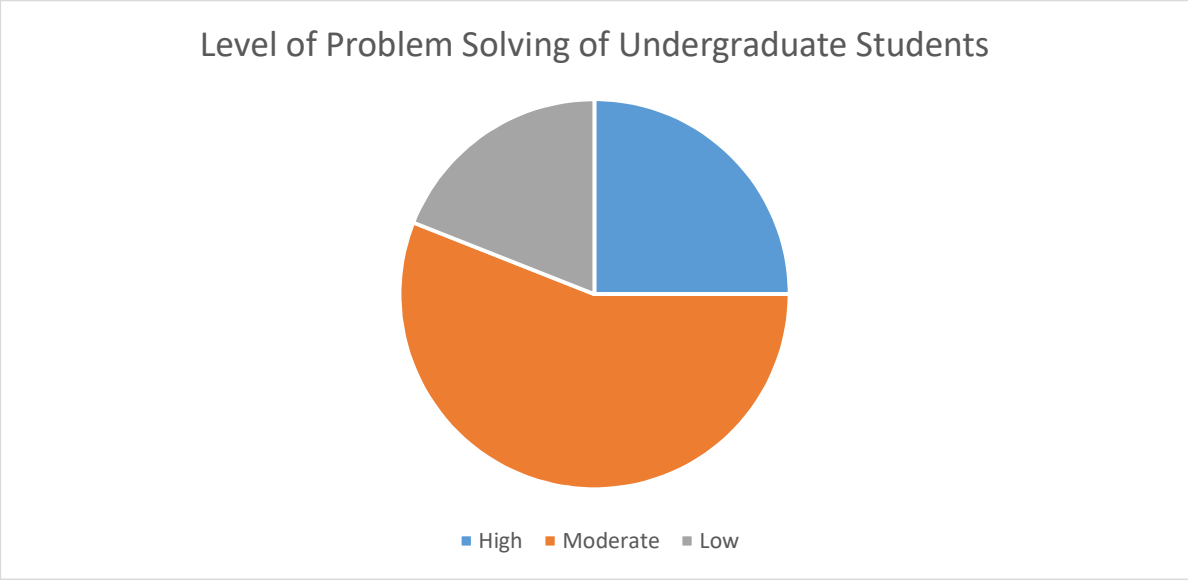
Variable	No. of Sample	Mean	Standard deviation	Level	Frequency	%
Problem Solving	300	18.32	4.13	High	76	25.33%
				Moderate	168	56%

	Low	56	18.67%

From table 2, it is clear that 25.33% of undergraduate students out of the total sample belong to the high-level group of Problem Solving, 56% of undergraduate students out of the total sample belong to the moderate level group of Problem Solving, and 18.67 % of undergraduate students of the total sample belong to the low-level group of Problem Solving. Hence the investigator concluded that the level of Problem Solving of undergraduate students is moderate.

Figure 2

Showing the level of Problem Solving of Undergraduate Students



Analysis of the Scientific Reasoning of Undergraduate Students with regard to Gender

The test of significance was used to compare the Scientific Reasoning scores of the selected samples based on the gender of undergraduate students. The critical ratio was used to calculate the difference between their mean scores. Table 3 provides details of the results obtained.

Table -3

Data and results of the test of significance of difference between mean scores of Scientific Reasoning of the Undergraduate Students with regard to Gender

Variable	Gender	N	Mean	SD	t - value	L.S
Scientific Reasoning	Male	130	19.63	4.15	4.776	0.01
	Female	170	16.91	5.73		

Table 3 indicates that the critical ratio achieved is 4.776, signifying significance at the 0.01 level.It indicates significant difference in scientific reasoning of undergraduate students with regard to gender. The study identified a difference in mean problem solving scores between male and female undergraduate students, with male students performing higher. At times, it could be because males tend to pay more attention to the intricacies of relationships and frequently make qualitative judgments based on the unique dynamics of specific relationships compared to females. The learning styles of both men and women could also significantly influence outcomes in this context.

Analysis of the Scientific Reasoning of Undergraduate Students with regard to Academic Streams

The test of significance was used to compare the Scientific Reasoning scores among selected samples of undergraduate students from different academic streams. The critical ratio was utilized to calculate the difference between their mean scores. Table 4 provides the details of the results obtained.

Table -4

Data and results of the test of significance of difference between mean scores of Scientific Reasoning of the Undergraduate Students with regard to Academic Streams

Variable	Academic Streams	N	Mean	SD	t - value	L.S
Scientific Reasoning	Arts	150	16.67	5.86	4.831	0.01
	Science	150	19.51	4.16		

Table 4 demonstrates that the critical ratio acquired is 4.831, signifying significance at the 0.01 level . It indicates significant difference in scientific reasoning of undergraduate students with regard to academic streams. An analysis of undergraduate students' problem solving revealed a difference in mean scores between science and arts students, favoring science students. Sometimes, it may due to the genuine interest of science undergraduate students in the subject matter, the rigorous academic curriculum in science programs ,exposure to hands on experiments and research opportunities.

Analysis of the Problem Solving of Undergraduate Students with regard to Gender

The test of significance was used to compare the Problem Solving scores of the selected samples based on the gender of undergraduate students. The critical ratio was employed to calculate the difference between their mean scores. Specific information about the obtained results is provided in Table 5.

Table -5

Data and results of the test of significance of difference between mean scores of Problem Solving of the Undergraduate Students with regard to Gender

Variable	Gender	N	Mean	SD	t - value	L.S
Problem Solving	Male	130	19.25	3.41	3.612	0.01
	Female	170	17.60	4.48		

Table 5 shows that the critical ratio obtained is 3.612, indicating significance at the 0.01 level.The study found a significant difference in problem-solving scores between male and female undergraduate students, with male students demonstrating higher average scores. Sometimes, it may due to the difference in the perception, communication skills, decision making skills, and critical thinking of male students compared to female students.

Analysis of the Problem Solving of Undergraduate Students with regard to Academic Streams

The test of significance was used to compare the Problem Solving scores of selected undergraduate students across different academic streams. The critical ratio was employed to calculate the difference in their mean scores. Table 6 provides detailed information on the obtained results.

Table -6

Data and results of the test of significance of difference between mean scores of Problem Solving of the Undergraduate Students with regard to Academic Streams

Variable	Academic Streams	N	Mean	SD	t - value	L.S
Problem solving	Arts	150	17.46	4.65	3.679	0.01
	Science	150	19.18	3.33		

Table 6 shows that the critical ratio achieved is 3.679, which is statistically significant at the 0.01 level.Analyzing problem solving across different academic disciplines in undergraduate students, the investigator found science students to have a higher average score than arts students, indicating a significant difference.The perceived difference in problem solving between science and arts undergraduate students might be more reflective of the distinct emphasis and methodologies within their respective academic domains.

Analysis of relationship between Scientific Reasoning and Problem Solving of Undergraduate Students

The correlation between Scientific Reasoning and Problem Solving among undergraduate students was determined through the use of the Karl Pearson product moment coefficient.Details regarding the results obtained are given in Table 7.

Table 7

Shows the relationship between Scientific Reasoning and Problem solving of Undergraduate Students

Variables	N	Co-efficient of correlation (r)	t	level of significance	SE	95% CI Lower	upper
Scientific reasoning							
Problem Solving	300	0.712	17.502	0.01	2.90	0.495	0.620

From table 7**,** it is seen that Karl Pearson's Product Moment Correlation (r) was applied to study the intensity of the relationship between Scientific Reasoning and Problem Solving of Undergraduate Students . The obtained value of r is 0.712 and is significant at the 0.01 level. ($r = 0.712$; $p < 0.01$). A robust, positive correlation was identified between the scientific reasoning and problem solving of undergraduate students.The intellectual challenge inherent in scientific disciplines often attracts students with a natural inclination towards problem solving, contributing to the development of high scientific reasoning skills.

Findings of the study

- The level of Scientific Reasoning of Undergraduate students is found to be moderate.
- The level of Problem Solving of Undergraduate students is found to be moderate.
- There exists significant difference between male and female Undergraduate students based on their Scientific Reasoning.
- There exists significant difference between Arts and Science Undergraduate students based on their Scientific Reasoning.
- There exists significant difference between male and female Undergraduate students based on their Problem Solving.
- There exists significant difference between Arts and Science Undergraduate students based on their Problem Solving.
- There is a positive relationship between Scientific Reasoning and Problem Solving of Undergraduate students.

Educational implications of the study

- The research proposes the development and application of diverse instructional methods tailored to meet the needs of undergraduate students, aiming to enhance their scientific reasoning and problem solving skills.
- Recognizing students with moderate abilities and offering focused assistance, including additional resources, workshops, or personalized tutoring, can contribute to improving their problem-solving skills and scientific reasoning abilities.
- Highlighting the integration of problem solving and scientific reasoning across different disciplines can augment students' capacity to apply these skills in varied academic settings.Integrate real-world applications into the curriculum, showcasing how problem solving and scientific reasoning are applicable and valuable in professional settings.
- To keep students engaged and motivated to learn, use dynamic and engaging techniques for instruction. This will provide a supportive learning atmosphere where students may continue developing their ability to solve problems and scientific reasoning abilities.
- A strong relationship between undergraduate students' use of scientific reasoning and their ability to solve problems suggests that fostering scientific reasoning may enhance overall problem solving ability of undergraduate students.
- Inform educators about the need for tailored instructional strategies.
- Guide curriculum development efforts to integrate more problem solving and scientific reasoning tasks across academic disciplines.
- Educational institutions can implement initiatives aimed at promoting gender equity.
- Institutions may use the research findings to inform their policies and practices related to admissions, academic support services, and resource allocation.
- Educators can benefit from professional development opportunities focused on fostering scientific reasoning and problem solving skills among undergraduate students.
- Contribute valuable insights to educational practice and policy, ultimately fostering a more inclusive and effective learning environment for undergraduate students across diverse academic backgrounds and genders.

Conclusion

This study investigates the relationship between scientific reasoning and problem solving in undergraduate students. Findings reveal a significant positive correlation, indicating that an increase in

scientific reasoning coincides with a corresponding increase in problem solving skills, and vice versa. The act of problem solving fosters the ability to evaluate and manage information, cultivate feelings of accomplishment, leverage prior knowledge and experiences, and actively utilize acquired knowledge (Sendağ & Odabaşı, 2009). Moreover, research by Hong et al. (2014) demonstrates that learners with extensive prior domain knowledge exhibit stronger scientific reasoning during inquiry tasks, while those with lower levels of knowledge perform less effectively in all aspects of scientific problem solving. Multiple studies highlight the interconnected nature of scientific reasoning and problem solving. Research by Alshamali & Daher (2016), Croker & Zimmerm (2012), and Kundariati et al. (2021) demonstrates their mutual dependence. Furthermore, Charysma et al. (2018) emphasize how scientific thinking enhances problem solving abilities and solution acquisition. This close relationship is reflected in the numerous analogies used in integrating scientific reasoning into both problem solving and science education practices (Brew, 2006; Fischer et al., 2018; Halpern et al., 2012). Moreover, research consistently shows that scientific reasoning effectively addresses problems and positively impacts students' science learning outcomes.It is vital to educate students to a highly dynamic and knowledge-based society. Zimmerman (2005) identifies two key approaches for fostering students' scientific reasoning skills:one way is to focus on allowing them to gain conceptual knowledge in specific areas of science, while the other way is to prioritise enabling them to use reasoning and problem solving techniques in an array of settings, like developing speculations, designing experiments, evaluating evidence, and reaching conclusions.

A defining characteristic of scientific thinking, applicable to both everyday situations and professional contexts, is the "deliberate quest for knowledge and coordination of theory and evidence" (Mayer et al., 2014).Reasoning is one aspect of abilities to think. Applying knowledge to solve challenges, make decisions, and attain goals is the cognitive method of inquiry (Remigio, Yangco, & Espinosa, 2014). According to Zimmerman (2005), being able to think rationally about methodologies for research, such as conducting experiments, interpreting empirical information, drawing inferences, interpreting research findings, and understanding intricate scientific theories, is a marker of having the ability to reason scientifically. Scientific reasoning is essential for individuals to tackle socioscientific issues and make informed evaluations of existing solutions (Evagorou & Osborne, 2013). It promotes responsible decision-making in both personal and societal contexts.The current study's findings, which suggest that scientific reasoning can predict problem strategies, have been reinforced by all of the prior described inquiries.

The results obtained from the present study are beneficial to undergraduate students, teachers, educators, curriculum and policymakers, stakeholders and the government. A few suggestions can be pointed out to nurture scientific reasoning and problem solving are to have frequent curriculum development efforts to integrate more problem solving and scientific reasoning tasks across academic disciplines, healthy arguments and analysis on issues and problems in general, involvement in minor and major projects, hypothesis generation and evidence-based conclusion-making, inculcate the habit of critical thinking, an attitude which involves the application of logic and the avoidance of bias, which in turn leads to an open and questioning seeking mind. Institutions may use the research findings to inform their policies and practices related to admissions, academic support services, and resource allocation.

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