**A Study of Reflective Thinking as a Correlate of Problem-Solving skills among Secondary School Physics learners**

**ABSTRACT**

The Study examines the relationship between Reflective Thinking and Problem-Solving skills among Secondary school Physics learners with a focus on potential differences by gender and educational boards. The data was collected from 1208 middle school students of grades 6 to 9 across the Greater Mumbai Region. Reflective Thinking was measured using a researcher-designed tool, while Problem-Solving ability was assessed through application-based Physics items tailored for each grade level. Statistical Analysis, including Pearson's Correlation Coefficient, revealed a statistically significant positive correlation between Reflective Thinking and Problem-Solving skills at all stages. Gender differences were found to be negligible, suggesting that these cognitive processes develop uniformly regardless of the educational board of study. The findings underscore the critical role of Reflective thinking in enhancing Problem-Solving skills in Physics, and they support the implementation of pedagogical strategies that foster Reflective Thinking for Problem Solving.

**Key words:** Reflective Thinking, Problem-Solving skills, Educational Boards, Physics

**INTRODUCTION**

“If your only tool is a hammer, then every problem looks like a nail” - Abraham Maslow

This adage is a metaphor used to describe the limitations of relying on a single approach, perspective, or thinking process to solve problems that may have different and simpler solutions. It warns us against narrow or rigid thinking and simultaneously suggests the importance of having set of skills. Different problems require different solutions. Albert Einstein rightly pointed out that we cannot solve problems with the same level of thinking that created it. The speed at which we solve problems determines our sound thinking process. There is no denying that our thinking dominates our ability to problem-solve.

Reflective thinking, on the other hand, is characterized by the analytical considerations we make while attempting to solve a problem. It is deeply rooted in our ability to analyze past experience or prior knowledge (Jin, G., & Wang, Y, 2020). One of the important goals of education and the primary goal of pragmatism is to produce reflective thinkers. Reflective thinking enhances the impact of any learning experience provided to the learner (Giada Di Stefano & Francesca Gino & Gary Pisano & Bradley Staats, 2014). Reflective thinking involves the process of analyzing and judging the events taking place. Reflection can be identified as a student's learning experience, where they realize an in-depth understanding of the content encountered adopting a critical approach (Čepienė, G., Žemaitaitytė, D., & Barkauskaitė, R. 2023; Strampel and Oliver, 2007). Dewey (1933) defined reflective thinking as any thought or knowledge and an information structure that supports attainment of its intended results, in an effective, careful and coherent way. This definition clearly connects reflective thinking to problem solving insofar as both are outcome driven or result oriented. Reflective thinking begins when a problem is recognized and ends when the problem is resolved. In addition, there is also an attempt to find the easiest possible solution to the problem and solve it better in the process (Kablan, Z., & Günen, A. (2021). Reflective thinking has a direct bearing on problem solving in mathematics and anxiety related to the same (Benato, M. A., & Espinosa, D. E. (2024)

Reflective thinking, from the perspective of problem-solving, is the habit of understanding a situation or a problem, generating alternative solutions to the problem, deciding important factors to be investigated, and evaluating the result (Kholid, M., Hidayat, A., & Azizah, S. N. 2021; Kızılkaya and Aşkar, 2009; Michalsky). There is a dearth of studies on how to conceptualize reflection and support the development of reflective capacity in students (Mann, Gordon, & MacLeod, 2009). Reflective Thinking is a skill that was emphasized mainly among professionals such as nurses or pre-service teachers (Kramarski, B., and Michalsky, T. 2010)

 The current study is an attempt to understand if the subjects within our academic setup provide room for developing problem-solving skills and does reflective thinking play any role in solving problems in school subjects such as Physics.

**Materials and method**

**Study design**

Research Design- A quantitative research methodology is used, namely the cross-sectional survey design (Creswell and Creswell,2017) to collect data about reflective thinking in middle school learners and their Problem-Solving skills in Physics.

**Setting and Participants**

Data was collected from 1208 middle school students across the greater Mumbai region. The students selected were from grades 6,7,8 and 9 across different boards namely the Maharashtra State Board of Secondary and Higher Secondary Education (MSBSHSE), Central Board of Secondary Education (CBSE), Council For The Indian School Certificate of Examinations (CISCE) and Cambridge Assessment for International Education (CAIE) form the Mumbai Metropolitan Region. These grades were chosen as Physics as a subject or as chapters in science, are introduced from 6th grade onwards. Moreover, scores of Physics matter if students are aspiring for the science stream after grade 10 or before (as in the case of CISCE/CAIE boards which offer subject choices after grade 8).

**Data collection**

The data was collected using a researcher-designed tool for measuring reflective thinking involved in problem solving, taking references from the Reflective thinking questionnaire designed by Kember et al (2000). There were 25 items in the scale with response options ranging between:

Table 1. Scale with response options

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Highly agree** | **Agree** | **Undecided** | **Disagree** | **Highly disagree** |
| 5 | 4 | 3 | 2 | 1 |

The reliability of the Reflective Thinking tool was assured by calculating the Cronbach alpha value:

Table 2. Cronbach alpha value

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **MSBSHSE** | **CBSE** | **CISCE** | **CAIE** |
| Average Cronbach's alpha Value | 0.823 | 0.851 | 0.737 | 0.907 |

For assessing Problem-Solving ability, a separate questionnaire was prepared by the researcher, which was validated by a team of experienced Physics teachers of different boards (MSBSHE, CISCE, CBSE & CAIE). The questions for problem solving were application-based questions of Physics that were grade-appropriate.

**Operational definitions**

Reflective Thinking - Reflective Thinking is the measurement of the level of decision making and problem solving while solving physics numerical problems, as measured by the tool created by the researcher.

Problem Solving - Problem Solving refers to the ability of individuals to use their previous knowledge and skills to solve the questions and problems in Physics.

**Null hypotheses**

1. There will be no significant difference in Reflective thinking of secondary school Physics learners on the basis of Gender.

2. There will be no significant difference in Reflective thinking of secondary school Physics learners on the basis of Types of Boards.

3. There will be no significant difference in Problem solving skills of secondary school Physics learners on the basis of Gender.

4. There will be no significant difference in Problem Solving skills of secondary school Physics learners on the basis of Types of Boards.

5. There will be no significant difference in the Correlation between Reflective thinking and problem-solving skills among secondary school Physics learners on the basis of Gender.

6. There will be no significant difference in the Correlation between Reflective thinking and problem-solving skills among secondary school Physics learners on the basis of the Types of Boards.

**Results and discussion**

1. There is a significant difference in Reflective Thinking of secondary school Physics learners on the basis of Gender so the null hypothesis is rejected. The *P* value is significantly lower than 0.05 and the t statistics is large, indicating a substantial difference in the Reflective Thinking scores of male and female learners.

**Gender differences in reflective thinking scores**

Gender differences in reflective thinking scores may depend on factors such as interest in physics (which is more in males), classroom teaching styles used, Cognitive gender differences were highlighted in a study by Anggraini, N. P., Budiyon o, & Pratiwi, H. (2019) where male and female learners showed different average in Higher order thinking skills.

In the data collected from 297 middle school students who are in 6th, 7th and 8th grades in Zonguldak city center of Turkey (Akdemirelif, 2018) a similar study was carried out and one of its significant findings was that female students’ reflective thinking skills are higher than male students’ reflective thinking skills which is contrary to the result obtained in this study.

Another contrary finding is a research article on the Relationship between Concept Mapping and Reflective Thinking (Pushpendra Yadav, 2020). Findings of this research paper highlighted that there is a minimal difference in the relationship between concept mapping and reflective thinking based on gender, and this difference points towards other factors. however, this study was with teachers as well as teacher educators, so the minimal difference could be attributed to age maturity and practice of reflective thinking.

In another study in Pakistan (Tabassum, F., Bibi, A., & Mazhar, U, 2024). On student teachers' Gender base differences of opinions about reflective practice were discovered in this study, as the female teachers showed more concern towards reflective practice as compared to their male colleagues. However, when reflective thinking is measured in terms of Physics learners in particular, males show a better performance than females. Possibly because males are culturally encouraged in STEM-related fields while females are encouraged in the humanities or social sciences. Males generally participate in physics-related competitions that probably sharpen their reflective thinking skills.

1. There is a statistically significant difference in Reflective thinking of Secondary School Physics learners based on Types of Boards (MSBSHSE, CBSE, CISCE, CAIE). Since the *P-value* is significantly less than 0.05, the null hypothesis is rejected.

Broadwise, there have been no detailed studies conducted in India that support or negate the relationship between reflective thinking and the different educational boards. However, the differences in reflective thinking across different boards is probably due to differences in curriculum structure, assessment styles, teaching methods, and emphasis on inquiry-based learning and Experiential learning with MSBHSE being the least and CAIE being the most. The CBSE and CISCE boards are in the middle with a stronger tilt in reflective thinking among the CBSE board learners.

1. There is a significant difference in Problem-solving skills of secondary school Physics learners on the basis of Gender. Since the *P*-value is significantly less than 0.05, males (mean = 41.125) have higher problem-solving scores compared to females (mean = 34.5). The null hypothesis is rejected.

Gender-wise male learners have better Problem-solving skills in Physics as compared to females. The social setup probably pushes males towards pursuing STEM-related subjects so from a very early age, interest in a technical subject as Physics is developed and nurtured. There is a great deal of literature (Zhu, Zheng,2007) that supports the fact that there are gender differences in mathematical problem-solving favoring males. Physics is a subject that uses math as a language for expression so the conclusion can be related to problem solving in Physics too.

Males (grade IX & X) have a predominance over females in problem solving when it comes to a subject like physics is supported in another research conducted in Pakistan ([F Sami](https://scholar.google.com/citations?user=4Rr81NIAAAAJ&hl=en&oi=sra), [MA Malik](https://scholar.google.com/citations?user=Cf9pQFkAAAAJ&hl=en&oi=sra), [AB Cheema](https://scholar.google.com/citations?user=e6xDCugAAAAJ&hl=en&oi=sra), 2023) wherein a REAPS Model(real engagement in active problem solving )was introduced to enhance problem-solving skills in physics.

Baran, M. (2016) states that while problem-solving abilities appear similar across genders, differences have been observed in self-efficacy. A study published in *Physical Review Physics Education Research* found that female students experienced significantly lower self-efficacy in physics compared to their male counterparts, which could influence their engagement and performance in the subject.

HDing, N., & Harskamp, E. (2006) examined how partner gender affects female students' problem-solving in physics education revealed that females' interaction content and problem-solving processes were more sensitive to partner gender than those of males. This suggests that mixed-gender collaborations might impact female students' problem-solving approaches.

1. There is a significant difference in Problem-Solving skills of secondary school Physics learners on the basis of the Types of Boards. The *P*-value is significantly less than 0.05. There is a statistically significant difference in problem-solving abilities among secondary school Physics learners based on the type of board (MSBSHSE, CBSE, CISCE, CAIE) with CAIE being the highest and MSBSHSE being the lowest. The null Hypothesis is rejected.

There have been many studies across the globe to understand how various curricula and teaching methodologies influence students' problem-solving skills across the globe. Program for International Students Assessment (PISA) evaluates the problem-solving skills of 15-year-olds across the OECD (The Organization for Economic Cooperation and Development) countries and there is no significant difference between the average science scores of male and female students. There is no significant relationship between problem-solving in physics and gender where PISA findings are published which is contrary to this study, probably because of the geographic differences and nation-wide policies towards STEM subjects.

An article titled "A Comparative Study of Problem-Solving Ability of High School Students of CBSE and State Board Schools of Aurangabad City" (Shaikh Imran Ramzan, 2020) examined the problem-solving skills of 8th-grade students from both Central Board of Secondary Education (CBSE) and state board schools and it was observed that students of CBSE school showed better problem-solving skills than the state board learners which aligns with this study.

There have been studies across countries like China, Germany, Malaysia and Korea where problem solving in sciences was investigated but there has been no specific study in India or abroad on the Board wise (MSBSHSE, CBSE, CISCE & CAIE) problem-solving ability in physics.

1. There is no significant difference in the Correlation between Reflective thinking and problem-solving skills among secondary school Physics learners on the basis of Gender. The null hypothesis is accepted as the data reveals a very strong and consistent positive relationship between Problem Solving and Reflective Thinking for male and female learners. The correlations range from 0.997 to 1.000 across all stages (from grades 6 to 9), indicating that as problem-solving abilities improve, reflective thinking abilities also improve. These relationships are statistically significant (*P*-values≤ 0.000), suggesting that problem-solving and reflective thinking are highly interconnected in female and male learners' academic performance in Physics.

Akdemir, E. (2018) of Turkey found no significant gender-based differences in reflective thinking skills and problem-solving abilities among students, suggesting that both male and female students possess comparable capabilities in these areas, which is in sync with this study.

Özdemir, E., & Yıldız, C. (2021) examined prospective mathematics teachers and found significant differences in reflective thinking between male and female participants, with females exhibiting higher reflective thinking skills. These differences could be attributed to age and experience, too.

Sintema, E. J., & Jita, T. (2022) researched on the math problem-solving skills of high school students and observed differences in the correlation between Problem-Solving and Reflective Thinking, gender-wise. These differences could be due to insufficient prior knowledge or even interest in Mathematics as s subject.

1. There is no significant difference in the Correlation between Reflective thinking and problem-solving skills among secondary school Physics learners on the basis of Types of Boards. The differences in correlation values among the boards are statistically negligible, and all correlations are significant. Therefore, the null hypothesis is accepted

In a study in Turkey byDeniş-Çeliker, H., & Dere, S. (2022) indicated no significant difference was found between the experimental and control groups in post-test scores regarding reflective thinking skills for problem-solving, which is in sync with this study.

Shareeja, A. M. C., & Gafoor, A. K. (2014) findings suggest that students employing metacognitive strategies, which involve reflective thinking, demonstrate improved problem-solving abilities, this study was done with Higher secondary learners in the state of Kerela and it supports the correlation between reflective thinking and problem-solving and board wise both nationally and internationally the correlation holds true.

**Educational Implications of the Study**

There are no significant differences in the correlation coefficients across MSBSHSE, CBSE, CISCE, and CAIE when examining the relationship between Reflective Thinking and Problem-Solving skills in physics for Grades 6 to 9, several implications arise:

**1. Uniform Cognitive Development Across Boards**

A similar correlation suggests that the ability to engage in Reflective Thinking and its impact on Problem-Solving skills is not strongly influenced by the curriculum or assessment style of any particular board. This could mean that core cognitive processes (like analysing, evaluating, and reasoning) develop similarly among students, regardless of board-specific differences. Using metacognitive strategies in the teaching and learning process will enhance the problem-solving skills (Güner, P., & Erbay, H. N., 2021) that will give impetus to competency-based education in India as proposed by the NEP 2020..

**2. Curriculum Variations May Not Significantly Affect Thinking-Problem Solving Link**

While different boards have different syllabi, teaching styles, and evaluation methods, these do not seem to significantly alter the fundamental relationship between reflective thinking and problem-solving in physics. This suggests that the conceptual and cognitive demands of Physics remain largely consistent across educational boards. Physics is a crucial subject in STEM education (Zavala, G., & Dominguez, A, 2018) and developing problem-solving skills will provide a base to foster 21st century skills.

**3. Focus on Pedagogical Strategies Over Board-Specific Differences**

Since no significant differences exist across boards, educators should emphasize teaching strategies rather than curriculum modifications to enhance problem-solving through reflective thinking. This reinforces the importance of inquiry-based learning, conceptual discussions, and other innovative teaching methods rather than focusing on board-specific content changes (India Today, 2024, September 6).

**4. Supports Generalized Educational Interventions**

Educational programs should aim to improve Reflective thinking and Problem-Solving skills in Physics that can be universally applied across boards, rather than requiring board-specific tailoring. This is particularly beneficial for teacher training programs, curriculum design, and standardized assessment frameworks.

1. **Cognitive Parity in STEM Education**

The similar correlation values indicate that both male and female students exhibit comparable patterns of reflective thinking and problem-solving in Physics. This suggests that gender does not inherently influence how students develop and apply these cognitive skills in Physics. With appropriate teaching techniques, the gender gap in Problem-Solving and Reflective Thinking can be bridged.

1. **Challenges to Traditional Gender Stereotypes in Physics**

Physics is often perceived as a male-dominated field, with assumptions that boys are naturally better at problem-solving in STEM subjects (Wang, N., Tan, AL., Zhou, X. *et al,2023)*. The absence of gender differences in correlation in this study implies that problem-solving in Physics is not biologically or cognitively gender-dependent. This finding reinforces the idea that educational opportunities, encouragement, and pedagogical methods play a more significant role in shaping STEM capabilities than gender itself. Gender neutral pedagogical strategies should be worked on for a more Reflective learner

1. **Supports Equal Access to STEM Opportunities**

If gender does not influence the correlation between Reflective Thinking and Problem-Solving skills, then barriers preventing girls from excelling in Physics are likely social or cultural rather than cognitive. This highlights the importance of encouraging female students to pursue STEM fields in school and beyond. Eliminate societal biases that may discourage girls from engaging in advanced Physics courses or careers. Promote mentorship programs and role models for young female students in physics (Li, Y., & Singh, C., 2023) who provide positive reinforcement and encourage female Physics learners.

1. **Promoting Reflective thinking from a very early age :** Science and Math are tools to promote reflective thinking (Young and Shtulman 2020). Teaching these subjects with Reflective Thinking skills activities will change their attitude towards studying mathematics and sciences, and increase their academic achievement (Erdoğan, F., & Şengül, S. 2019)
2. **Suggestion to Focus on other Factors Influencing Reflective Thinking:** If gender is not a differentiating factor as implied by this study, then future research can explore:
	* **Learning environments:** Are students getting equal opportunities in class? Or are Suitable learning activities provided in the classrooms that foster Reflective thinking?
	* **Parental and societal influences:** Do expectations differ for boys and girls in physics?
	* **Confidence levels in problem-solving:** If there is a strong positive correlation between Reflective thinking and Problem-solving skills, Can developing Reflective Thinking skills boost and nurture Problem-Solving ability?
	* **A Paradigm shift from Book to Brain :** Research should support a shift from rote memorization to actual Problem Solving , Critical Thinking, Reflective Thinking and Decision making. This can be accomplished through research in varied assessment patterns.

**CONCLUSION**

The finding suggests that Reflective Thinking and Problem-Solving are fundamental cognitive skills that transcend curriculum differences. It emphasizes the need to focus on universal pedagogical improvements rather than specific board-based interventions to enhance students' Problem-Solving abilities in physics. The finding debunks gender-based cognitive differences in physics problem-solving and suggests that both boys and girls develop these skills similarly. It reinforces the need for gender-inclusive teaching strategies and equal encouragement in fostering learners' autonomy, ensuring that any observed gender gaps in Physics education are addressed at the social and institutional levels rather than assumed to be cognitive differences. The paper aims to promote Reflective Thinking among school children as a reflective thinker will be able to find unknown solutions to known problems with all the available information at hand.

**Ethical Approval:**

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

**Disclaimer (Artificial intelligence)**

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Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1. Grammarly for verbal flow

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