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Relationship among Secondary School Students' Physics Academic Achievement Scores, Conceptual Knowledge and Problem-Solving Skills

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Abstract: The study aimed to explore how improving conceptual understanding and problem-solving skills in secondary school students can lead to better academic success in the field of physics. The research utilised a multistage sampling technique, selecting 64 schools as clusters and randomly selecting 2350 male and female students for the study. The focus is on increasing enrolments and enhancing the overall quality of education by improving students' abilities in critical thinking and problem-solving. The ultimate goal is to boost academic achievement and ensure a higher standard

of education in the sector. Two self-designed achievement tests were utilised in this research based on the updated Bloom's taxonomy to assess the conceptual understanding and problem-solving abilities of students. Conceptual Knowledge Test (CKT) was of 20 MCQs items whereas the Problems-Solving Skills Test (PSST) consisted on five problem-based supply type questions. The tests were validated by the experts. The pilot study revealed 0.87 of reliability for CKT and 0.67 for PSST. This reliability was verified with Ferguson delta 0.99 for both tests. The item difficulty and discrimination index remained moderate. The significance of the variables was determined using an independent samples t-test, while the correlation between the variables was assessed using the Pearson product moment correlation. The analysis revealed moderately significant relationships between the variables. The study revealed statistically significant gender differences in academic performance, with females outperforming males across all variables examined. Therefore, educators are advised to implement concept learning strategies and problem-based learning approaches in order to improve students' conceptual understanding and problem-solving abilities.

Keywords: Physics, Academic Achievement, Conceptual Knowledge, Problem solving Skills, Revised Bloom's Taxonomy.

Introduction

Education plays a crucial role in shaping the attitudes of learners towards their learning environment. A well-rounded education equips individuals with the necessary skills to compete on a global scale. The quality of education directly impacts the quality of students it produces. To enhance education quality, it is essential to focus on improving students' understanding of key concepts and developing their skills within an educational setting.

Furthermore, in today's fast-paced world, students must possess 21st-century skills such as problem-solving, academic proficiency, and creativity. These skills are vital for success in an increasingly complex and interconnected world (Assem et al., 2023).

In our society, tests are considered helpful tools for decision making for learners. Further these tools are in assessing students' knowledge, skills, abilities and academic achievements (Castro, 2023). In physical sciences, Physics is considered an important subject that is more helpful in understanding the complexities of this nature in this modern world (Martawijaya, et al., 2023). Furthermore, physics holds a dominant position and considered a difficult subject to understand, due to this, its learning and understanding will be taken seriously. Physics is playing a vital role in our society, industry and in other science subjects (Rahmat et al., 2023).

Poor performance is the major issue in education sector at secondary school level. In some researches it is observed that it is due to the gender difference because females are less interested in physics subject than males, it is same at performance level (Martawijaya, et al., 2023). Main indicators affecting the quality of education of students may be enlisted as students' ability to solve problems and see things in critical point of view (Martawijaya, et al., 2023). Students' ability to solve problems depends upon their conceptual understanding of things. Over the last decade these factors are mostly studied (Bahar & Aksut, 2020). Teachers' work commitment and performance can be evaluated based on data of academic achievement, while students' mastery of concepts and problem-solving skills is directly correlated with their academic success. High levels of achievement are tied to proficiency in knowledge, abilities, and skills (Saroyan & Trigwell, 2015).

The findings of this research study are significant for science students to get knowledge of physics by gaining concepts of learning and skills about solving the physics problems as well as daily life problems and may be applied in their future studies. This study is also important for physics teachers as it highlights the need for improving their understanding of concepts and problem-solving techniques in order to enhance their teaching methods and effectively educate their students in physics. It may help science teachers to practice conceptual knowledge and problem-solving skills in real classroom teachings at secondary school level (Ummah & Yuliati, 2020). This study is also beneficial for other stakeholders such as curriculum developers in developing such activities and learning material which is helpful for secondary school students' concepts building process and their skills about problem solving skills in acquiring Structured Learning Outcomes (SLOs) of physics subject under Revised Bloom's Taxonomy.

Teachers can improve their training by incorporating both conceptual knowledge and problem-solving skills into their training materials. This will not only benefit the teachers themselves, but also the students they educate. Science teaching institutes can also utilize this approach to enhance their curriculum and help students develop critical thinking and understanding of key concepts in their subjects (Tsivitanidou et al., 2021).

Research Problem

The literature review suggested the important role of conceptual knowledge for the high academic achievement (Assem et. al., 2023). Students may have higher scores and performance in their academic activities if they have conceptual understanding of the subject, especially in the subject of sciences (Castro, 2023). Malik et al. (2019) and Susanti et al. (2021) have suggested problems solving another important variable for higher academic achievement and success in science subjects. The problem solving skills are defined as ability to handle difficult or challenging and unexpected workplace problems confidently and skilfully (Mirkamali et al., 2017; Suprapto et al., 2020). Conceptual knowledge is elaborated as the understanding and comprehension of ideas, principles, and theories etc. which are abstract in nature and may not have any physical occurrences (Taslidere, 2020). The academic achievement is defined as gain of higher scores/grades and performing skillfully for the solution of any given problem (Wider, & Wider, 2023).

Literature has highlighted the importance of both conceptual knowledge and problem-solving skills in the realm of education. However, there remains a need for empirical evidence to support these claims. This study aimed to address these gaps by investigating the relationship between secondary school students' conceptual knowledge in physics and their ability to solve practical problems. Additionally, we will explore whether students' problem-solving skills and conceptual knowledge have an impact on their academic achievement. This study was conducted to answer these questions empirically by finding out the relationship among secondary school students' academic achievement scores, conceptual knowledge, and problem-solving skills in the subject of physics. Teachers may have this study as empirical evidence to focus on their teaching methods to develop students' conceptual knowledge and problem-solving skills to have higher academic achievement in the subject of physics. At the same time the study results would be helpful for secondary school students to develop their conceptual knowledge and problem-solving skills to have high academic achievement.

Research Focus

Main concern is that do high academic scores reflect students' higher level conceptual knowledge and explain the students' problem-solving skills? There are few studies rigorously explored the relationship among above discussed variables. To find out the in-depth correlation

among variables is essential (Wider, & Wider, 2023). There is a lack of comprehensive studies exploring the relationship between academic scores, conceptual knowledge, and problem-solving skills. It is crucial to delve into these correlations to gain a deeper understanding. Improved instructional designs can be implemented to help educators better assess and develop students' problem-solving abilities in various contexts, leading to a greater understanding of concepts and skills. This study focused on investigating these relationships in physics students at the secondary level.

Research Aim

The study was designed for the following aims/objectives:

1. The relationship between students' conceptual understanding and academic scores in the subject of physics at secondary school level.
2. The relationship between students' ability to solve problems and their academic achievement in the subject of physics at secondary school level.
3. The effect of gender on conceptual learning, ability to solve problems, and academic scores in the subject of physics at secondary school level.

Following were the research questions addressed in the study based on research aims/objectives:

1. What is the relationship between students' conceptual understanding/knowledge academic scores/achievement in the subject of physics at secondary school level?
2. What is the relationship between students' ability to solve problems their academic achievement in the subject of physics at secondary school level?
3. Is there any effect of gender on conceptual learning, ability to solve problems, and academic scores in the subject of physics at secondary school level?

Literature Review

Academic achievement is recognized as a crucial element in contributing to the development of a nation in any field of education. It is essential to establish a strong foundation of academic achievement in order to effectively align the scientific and spiritual aspects of learning (Suharyat et al., 2022). National education policies are formulated with the aim of equipping students with problem-solving skills and a deep understanding of concepts (Castro, 2023). The primary focus is on improving the quality of education and ensuring academic success by fostering conceptual understanding and practical problem-solving abilities. Failure to meet these objectives can result in significant financial and spiritual losses for educational institutions (Mirkamali et al., 2017).

Concept is the mental image formed by identifying key features and characteristics of an entity or group of entities (Pols & Dekkers, 2024). Bahar and Aksut (2020) define concept as encompassing all words, excluding proper nouns that represent a specific place, object, or idea. Conceptual learning involves children grasping ideas and being able to apply them in different situations to solve everyday problems, a departure from the traditional method of rote memorization (Assem et al., 2023). Procedural knowledge, on the other hand, refers to understanding groups and specific categories, along with strategies and skills that aid in breaking down tasks or content (Mustofa & Hidayah, 2020). Unlike procedural knowledge, which focuses on the mechanics of a task, conceptual

knowledge delves into a deeper understanding of an idea through the formation of a mental image (Saroyan & Trigwell, 2015).

The ability to identify the nature and strength of a problem, deconstruct it in pieces and apply the effective strategies to solve the challenges related to it is defined as problem solving skills (Castro, 2023). Controlling the emotions and removing the obstacles faced to solve the problem is also problem-solving skill. Problem solving is complete procedural way of doing an action (Maielfi, 2021). The sequence followed in problem solving comprises define faced problem, do brainstorming for selecting any effective solution, pick a solution that works for the faced problem, test the selected solution or apply the solution to solve the problem, then review the results to see either they are as per the required end (Maknun, 2020; Martawijaya et al., 2023). This procedure helps a person to solve problem. Students, whether they are in the science or arts disciplines, should have the ability to solve problems. The success of one's life hinges on their problem-solving skills. It is essential for the education system and teachers to prioritize enhancing students' problem-solving abilities (Rahmat et al., 2023).

It is students' ability to solve potential problems that enable them to think procedurally, act purposely, and look things in fresh perspectives (Kwangmuang et al., 2021). Additionally, they learn how to manage time, and develop patience (Martawijaya et al., 2023). Important thing for students is to identify problem at its earliest stage to prevent it from escalating a serious matter which requires serious injuries (Saroyan & Trigwell, 2015). Every problem does not have the same composition and same solution cannot be applied for them. Child should be trained to view problems in different angles and aspects to opt proper solution without time wasting (Malik et al., 2019).

The study aimed to investigate the relationship between conceptual knowledge in physics and academic achievement among students. The researchers collected data from a sample of students and analysed it to determine if there was a correlation between the two variables.

The results of the study showed that students who had a strong conceptual understanding of physics were more likely to have higher academic achievement in the subject. This suggests that conceptual knowledge plays a crucial role in students' success in physics.

Furthermore, the study also found that students who performed well academically in physics were able to demonstrate higher levels of problem-solving skills. This indicates that academic success in physics is not only about memorizing facts and formulas, but also about being able to apply concepts to solve real-world problems.

Overall, the study provides empirical evidence to support the importance of developing conceptual knowledge and problem-solving skills in physics for students to achieve higher academic success. Science teachers and students can use these findings to guide their approach to teaching and learning physics effectively.

Theoretical Framework

Cognition plays a crucial role in learning process and learning is closely linked with cognitive phenomenon (Wider, & Wider, 2023). As explained by theorists that pondering and reasoning is involved in learning and higher order thinking. Advanced learning is also based on concept learning (Doleck, et al., 2017) and on skills to solve potential problems (Mulyanto et al., 2018). Conceptual understanding and problem-solving skills are conscious processes as pointed by theorists in which conceptual learning and problem-solving skills are found (Kulgemeyer et al., 2020).

It was suggested by Bloom in 1956 that there are six cognitive learning levels, widely recognized as cognitive domains. Wider and Wider (2023) later transformed these levels from nouns to verbs. These levels are closely interconnected, ranging from easy to difficult and simple to complex (Istiyono et al., 2020). The levels have been renamed: knowledge is now remember, comprehension is now understand, application is now apply, analysis is now analyse, synthesis is now create, and evaluation is now evaluate (Khan & Ghosh, 2021). Wider and Wider (2023) have also moved create to the highest level of the learning domain (Malik et al., 2019).

The first two stages involve recalling learned information and comprehending concepts to explain them. The third and fourth levels focus on the ability to apply learned concepts and principles to analyse problems and find solutions (Hidaayatullaah et al., 2020).

Piaget's learning theory has step by step guidelines to explain the process of learning. Piaget's four stages psychological development theory (Doleck, et al., 2017) as well as the problem solving skills as cognitive learning process (Mulyanto et al., 2018) have focused conceptual learning and students' ability to solve their potential problems.

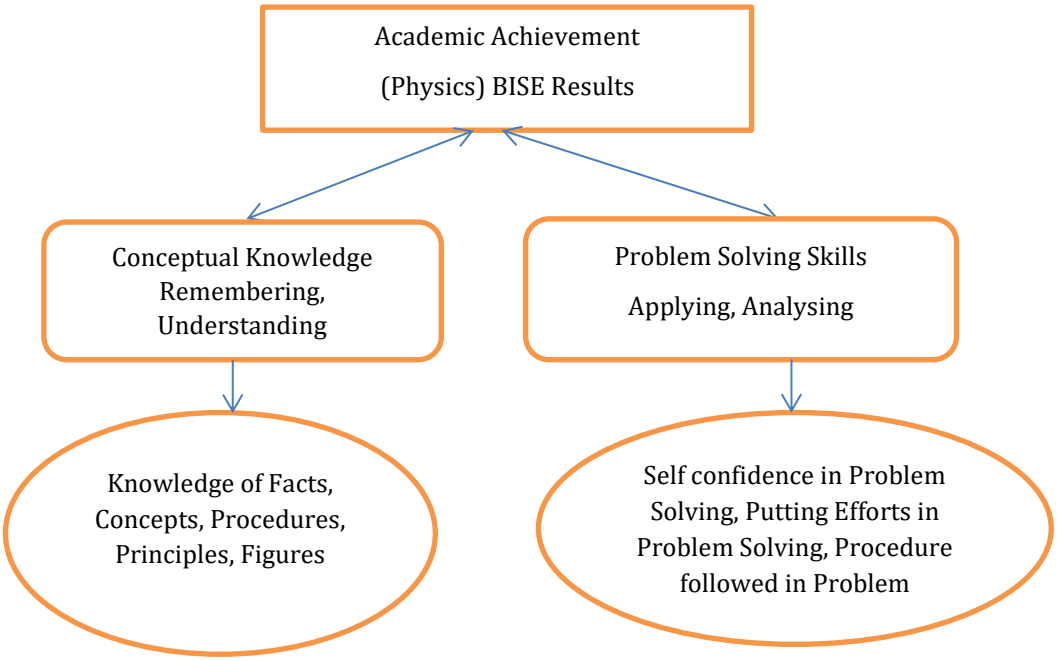
Conceptual learning and problem solving are both cognitive phenomena, in this regard this study comes under concept learning cognitive theories and learning on the base of problem solving. It is supported by Doleck et al. (2017) and Mulyanto et al. (2018) these variables and their processes comes under the under the guidelines of cognitive theories and should be studies under these theories.

Conceptual Framework

The diagram in Figure 1 illustrates the framework of this research study. The primary aim is to explore the correlation between students' problem-solving abilities, conceptual understanding, and academic achievement (referred to as scores) in the field of physics. This study will focus on four levels of RBT: remembering, understanding, applying, and analysing, as outlined in the diagram.

Figure 1

Conceptual Frameworks



Materials and Methods

Academic achievement, conceptual knowledge, and students' problem-solving skills play crucial roles in the teaching-learning process. Understanding how these constructs interact with each other is essential for educators to enhance their teaching methods and for students to improve their learning strategies. A recent correlational study was conducted to explore the relationships among academic achievement, conceptual knowledge, and problem-solving skills. The findings of this study can provide valuable insights for educators and students striving to excel in their educational pursuits.

Sample and Participants

In 2019, a total of 2,350 students from a pool of 113,706 who passed the 9th grade physics examination of BISE Lahore were selected for a study. The selection process involved a multi-stage sampling technique. Initially, 64 schools (32 boys' and 32 girls' schools) were randomly chosen as clusters. In the second stage, 2,350 students (1,175 males and 1,175 females) were selected using a simple random sample technique. Within each school, approximately 37 students were selected through a lottery method.

Instruments and Procedures

Two achievement tests were developed for this study to collect data for investigating the relationship among variables. The items at different levels such as remember, understand for Test of Conceptual Knowledge and apply and analyse levels for Test of Problem-Solving Skills were developed as per the cognitive domain of RBT. Test content was taken from textbook of physics developed and published by PCTB for 9th grade students in session 2022-2023. These tests were as BISE pattern.

Anderson (2005) further revised the Bloom's Taxonomy constructing two dimensions of the domains. The horizontal dimension is comprised of the cognitive domains, including Facts, Concepts, Principles, and Procedures. The vertical dimension encompasses the content dimension, including Remembering, Understanding, Applying, and Analysing (Table 1).

Table 1

Dimensions of Revised Bloom's Taxonomy

		Content Dimension			
Cognitive Dimension		Facts	Concepts	Principles	Procedure
	Remembering				
	Understanding				
	Applying				
	Analysing				
	Others				

Mostly three formats multiple choice questions, constructed response questions and performance-based formats were used in the field of research but multiple-choice questions format is widely used due to easy to administer, grade and analyse and results are often generalisable. If test is well designed it can cover different cognitive behaviours, knowledge content as well as higher order thinking skills like application of principles (Castro, 2023). Similarly, to assess the higher

abilities such as problem-solving skills constructed response and performance-based tests are more suitable.

Two tests were created: the Test of Conceptual Knowledge (TCK) and the Test of Problem-Solving Skills (TPSS). The TCK included 10 multiple-choice questions (MCQs) focusing on remembering and 10 questions aimed at understanding, with each question worth 1 mark and a time limit of 30 minutes. The TPSS consisted of constructed response and performance-based items, with 3 apply and 3 analyse items, each worth 5 marks according to the BISE scheme, and A Test duration of one hour. A rubric was used to grade the TPSS. Both tests were developed using a table of specifications.

The instruments underwent validation by a panel of six experts who provided feedback for improvements to ensure validity. The Test of Conceptual Knowledge demonstrated a reliability of 0.87, while the Test of Problem-Solving Skills showed a reliability of 0.67, both considered adequate based on Cai et al. (2021). Additionally, the Ferguson delta value of 0.99 was calculated for both tests for further verification of reliability. Through data analysis, the difficulty level, discrimination power, and point bi-serial characteristics of the test items were examined to ensure item reliability. Further details on item analysis are provided below (Table 2).

Table 2

Finalized Versions of Tests Evaluation of TCK and TPSS

Tests Parameters	Desired Values	Finalized Tests Values
Item Difficulty Index	[0.3, 0.9]	0.41-0.71
Item Discrimination Index	≥ 0.3	0.17-0.59
Point Bi-serial Coefficient	≥ 0.2	0.19-0.24
Cronbach Alpha	≥ 0.7	0.85, 0.67
Ferguson Delta	≥ 0.9	0.99

All the parameters shown in table 1 are in accordance to the desired values. Only 0.67 values is slight less than desired value but it is adequate according to Banda and Nzabahimana (2021), the value will be considered adequate if value lies in 0.60 to 0.79.

Data Collection Procedure

After taking permissions from concerned authorities then data were collected from selected students from nominated schools. Students were briefed about the purpose and significance of the study. Rubrics were developed for marking of tests validated by four experts of the field and tests were marked according to developed rubrics. Results of 9th grade students of physics subject were collected from concerned class teacher and verified from school record and annual gazette 2023 of BISE Lahore.

Results

A data analysis was carried out through descriptive and inferential statistics. The descriptive statistics explains the understanding of different dimensions of data while inferential statistics explains the relationship and difference among variables; academic achievement, ability to solve problems and having conceptual understanding of the things.

Table 3

Gender Wise Analysis of Academic Scores in the Subject of Physics, Ability to Solve Problems, and Conceptual Understanding

Variable	Gender	N	Mean	SD
Academic Achievement	Males	1175	37.19	9.391
	Females	1175	39.03	9.886
Conceptual Knowledge	Males	1175	13.05	4.167
	Females	1175	14.73	3.446
Problem Solving Skills	Males	1175	9.45	5.906
	Females	1175	12.07	5.920

Note. Mean scores ranges from Academic Achievement 1 to 60, Conceptual Knowledge from 1 to 20, Problem Solving Skills from 1 to 30.

It can be observed from Table 3 that females have higher mean scores than males in all variables - academic scores, conceptual understanding/knowledge, and problem-solving ability in the subject of physics. Specifically, girls scored an average of 39.03 in academic scores, 14.73 in conceptual understanding/knowledge, and 12.04 in problem-solving ability, compared to boys' average scores of 37.19, 13.05, and 9.45 respectively. Interestingly, there are greater variations in girls' academic achievement and problem-solving skills, while there are fewer variations in their conceptual knowledge results.

Table 4

Relationship among Students' Academic Scores, Conceptual Understanding/Knowledge and Ability to Solve Problems

Variables	N	Pearson r	Significance
Academic Achievement and Conceptual Knowledge	2350	0.282	0.000
Academic Achievement and Problem-solving Skills	2350	0.384	0.000

*p <.05

To investigate the relationship between variables, Pearson product moment correlation test was applied. It is evident from Table 4 that there is weak level of significant relationship between academic scores/achievement and conceptual understanding/knowledge i.e. 0.282 and likewise there is also mild weak significant relationship was found between academic achievement and problem-solving skills i. e. 0.384 although it is slighter better than as in first case but same as in relationship.

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Table 5

T-test Gender Wise Comparison of Students' Academic Scores/Achievement, Conceptual Understanding/Knowledge and Ability to Solve Problem

Variable	Gender	Mean	SD	t-value	df	Sig.(p)*	G
Academic Achievement	Boys	37.19	9.391	-4.641	2347	.000	.19
	Girls	39.03	9.873				
Conceptual Knowledge	Boys	13.05	4.167	-10.607	2348	.000	.44
	Girls	14.73	3.446				
Problem Solving Skills	Boys	9.45	5.906	-10.755	2347	.000	.44
	Girls	12.07	5.920				

Note. Mean scores ranges from Academic Achievement 1 to 60, Conceptual Knowledge from 1 to 20, Problem Solving Skills from 1 to 30.
*p < .05, N=1175.

Table 5 showed statistical results of variable comparisons. Independent samples t-test statistic was used for the mean score comparison of academic achievement, conceptual knowledge and problem-solving skills in physics subject. The results revealed that female students had better performance in all the selected variables as compared with male students. In academic achievement of physics, performance of girls' (M=39.03, SD=9.873) is better than performance of boys (M=37.19, SD=9.391). The result is statistically significant, t (2347) = - 4.641, p < .05. Hedges value (g=0.19) shows low effect size and practical significance. In academic achievement female students showed better results than male students.

In the same way in conceptual knowledge and the ability to solve problems female students had better results as compared with male students. Conceptual understanding/knowledge of physics comparison also revealed better performance of female students than male students as girls' (M=14.73, SD= 3.446) is better than male students (M=13.05, SD=4.167). Result is again statistically significant, t (2348) = -10.607, p < .05. Hedges value (g=0.44) reflects moderate level effect size and practical significance. Males' students' results show more variability compared to females' students' results.

Likewise results depicts that female students' comparison (M= 12.07, SD= 5.920) in problem solving skills is better as compared with male students (M= 9.45, SD= 5.906) conditioned t (2347) = -10.755, p < .05. Hedges effect size value (g=0.44) again same as in case of conceptual knowledge having moderate level effect size and practical significance. Low variation of results is in girls' students than boys' students.

Table 6

Students' t-test Results Comparison of Remember, Understand, Apply and Analyse Levels Gender-wise

Variable	Gender	Mean	SD	t-value	df	Sig.(p)*	g
Remember	Boys	6.54	2.272	-9.417	2348	.000	.34
	Girls	7.36	1.948				
Understand	Boys	6..49	2.281	-9.635	2348	.000	.39

	Girls	7.34	1.991				
Apply	Boys	5.89	3.256	-9.852	2348	.000	.34
	Girls	7.01	3.244				
Analyze	Boys	3.79	2.291	10.451	2348	.000	.48
	Girls	5.07	2.966				

Note. Mean scores for the Remember and Understand levels range from 1 to 10, while scores for the Apply and Analyse levels range from 1 to 15.

*p < .05, N=1175.

Table 6 presents the independent sample t-test results for physics achievement based on cognitive levels of Bloom's taxonomy - remember, understand, apply, and analyse. The analysis showed that female students outperformed male students across all parameters. Specifically, in the remember cognitive level, female students (M=7.36, SD=1.948) performed significantly better than male students (M=6.54, SD=2.272), with a t(2348) = -9.417, p < .05. The Hedges value (g=0.34) indicates a low to moderate effect size and practical significance. Additionally, there was greater variability in the remembering level results for male students compared to female students based on standard deviation.

Similarly, when it comes to the remember level of the cognitive domain, female students outperformed male students. Specifically, in the subject of physics, female students (M=7.34, SD=1.991) achieved higher scores than male students (M=6.49, SD=2.281), with a statistically significant difference found (t(2348) = -9.635, p < .05). The Hedges value (g=0.39) indicated a low to moderate effect size and practical significance. Furthermore, there was greater variability in the results of male students compared to female students, as evidenced by the standard deviation.

Similarly, the findings indicated that female students (M= 7.01, SD= 3.244) outperformed male students (M= 5.89, SD= 3.256) in the application level of the cognitive domain in the subject of physics, with a significant t(2348) = -9.852, p < .05. The Hedges' effect size value (g=0.34) was consistent with the results found in the recall level, showing a small to moderate effect size with practical significance. Additionally, there was slightly less variability in the results of female students compared to male students in terms of standard deviation.

Likewise the results showed that female students' performance (M= 5.07, SD= 2.966) in analyse level of cognitive domain is better than male students (M= 3.79, SD= 2.291) in the subject of physics conditioned t(2348) = 10.451, p < .05. The Hedges effect size value for the moderate level effect size and practical significance of the analyse level, was found to be g=0.48. However, it is important to note that there was a greater variation in the results of female students compared to male students, as indicated by the standard deviation. This unexpected finding suggests that there may be other factors at play that are influencing the results for female students differently than male students at the analyse level. Further research may be necessary to better understand the reasons behind this disparity in results.

Discussion

The main purpose of this study was to find out the relationship between male and female students' performance in physics subject result/achievement, the conceptual understanding of the subject content, and their ability to solve problems related to their daily problem. Remembering, understanding, applying, and analysing are key cognitive factors that contribute to enhancing these skills. Each of these factors has a unique and important impact on cognitive development.

In answer to the initial research question, the data indicated a modest yet significant positive correlation between academic performance and conceptual understanding in students' physics education. This suggests that a strong grasp of fundamental concepts is crucial for promoting more effective learning outcomes among students and holds considerable importance (Aslan, 2021). The findings highlight that a deficiency in conceptual knowledge leads to a decline in academic achievement, mirroring the conclusions drawn by Khan et al. (2017) who also observed a direct relationship between these factors where an increase or decrease in one corresponds to a similar change in the other. If students' increase their concept learning ability they can became more efficient in solving the problems of physics as well as out of the prescribed syllabus (Azhary et al., 2020). There is positive effect of conceptual knowledge on students' concept learning capability (Ardianti, et al., 2020). The process of concept learning is beneficial for students studying physics. This conclusion is corroborated by the results of studies documented in the literature (Castro, 2023).

Based on the data from the second research question, it was found that academic achievement scores are directly linked to problem-solving skills, with a significant positive correlation observed. The study conducted by Karyadi et al. (2018) confirmed that students who possess strong problem-solving abilities tend to perform better academically compared to those with weaker skills in this area. Moreover, the research highlights that the ability to solve problems has a beneficial impact on students' understanding and performance in physics. Notably, the study also showed that low achievers exhibit limited progress in developing their problem-solving skills, while high achievers demonstrate significant improvements in this area. It is concluded from that those students' have this ability easily solve their problems. This problem-solving ability can helpful for students in their daily life problems as supported by (Azhary et al., 2020).

Significant differences in mean scores were found in response to the third research question regarding students' achievement scores, conceptual knowledge, and problem-solving skills. Female students outperformed male students in all three areas, a finding supported by previous research by Fatoba and Aldejana (2014). Similarly, Rahmat et al. (2023) also found that female students performed better in physics learning compared to male students. However, it is important to note that some studies suggest that male students may excel in physics learning. In the Pakistani context, cultural factors may play a role in these results, as well as the greater commitment of female students compared to male students. Taslidere (2020) also found similar results, highlighting a significant difference in problem-solving abilities between male and female students.

Conclusions and Implications

It can be concluded that male and female students have less conceptual knowledge and problem-solving skills in accordance with their academic results in subject of physics at secondary school level. This demonstrates that science students have less in-depth knowledge of concepts as well as problem solving in physics because their academic achievement scores are low. While the findings show a clear impact on academic achievement, conceptual The study found that there is a weaker relationship between knowledge and problem-solving skills. Female students had higher results in both variables compared to male students, and this trend was also seen in the cognitive domains of remembering, understanding, applying, and analysing. The study suggested that low academic achievement may be linked to low conceptual knowledge and problem-solving abilities, and vice versa. Overall, the study concluded that low achievers had lower performance in all aspects, while high achievers showed higher performance.

Based on the study findings, the following are the implications of the research:

1. It is advised that secondary school students enhance their conceptual understanding of physics by utilising various teaching and learning methods, as research shows a strong correlation between conceptual knowledge and academic success.

2. Secondary school students are also recommended to develop their skills in order to solve problems. It is also beneficial for them to experience improved academic performance during their time in school.

3. Male students are recommended to have concentration on their physics subject to improve their academic achievement by developing their conceptual understanding of the subject and problem-solving skills.

4. It is recommended that science teachers at the secondary school level use teaching methods that enhance students' conceptual understanding of the subject and empower them to effectively solve problems in their field of science or everyday life.

5. Teachers are recommended to use strategies for teaching physics subject to improve male students' learning in the subject of physics. Male students may vary in their interests and preferences for learning strategies.

Suggestions for Future Research

Students' conceptual knowledge and problem-solving skills at the secondary school level could potentially be significant predictors of high academic achievement. This study was conducted using various methodologies such as experimental methods. It could provide valuable insights for both teachers and students. The study result might be broadened by selecting larger sample for more reliable results. Teachers should be considered as valuable contributors to the study by seeking out and incorporating their insights and perspectives. Another crucial recommendation for future research is to improve academic achievement through the development of more valid and reliable testing methods, rather than relying solely on the annual results announced by external bodies such as the Board of Intermediate and Secondary Education (BISE). This approach could lead to more impactful study outcomes.

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Conflict of Interest

None.

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