The Correlation between Mathematics and Physics Achievement of Senior High School Students

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Abstract. Physics and mathematics are the two most closely related natural rudimentary subjects. In the study of physics, often need to rely on mathematical rigorous reasoning and argumentation and need to use a variety of mathematical methods for investigation, reasoning, calculus, test, discussion, but students often appear in these difficulties. To explain the influence of mathematics achievement on physics achievement from the high school mathematics achievement and physics achievement. The results of math and physics in the first semester of 6 classes of senior high school student’s grade 12 were selected, and the data were analyzed with SPSS.22 software, and three students of different learning abilities were interviewed in detail. The innovation of this paper lies in the use of hierarchical research methods to compare classes of mathematics achievement and physics achievement. The conclusions are (1) in objective level, there is a positive linear relationship between math achievement and physics achievement; (2) on the subjective level, students accept the view that the performance of mathematics can promote the performance of physics; students' subjective cognition will affect their cognitive structure and learning behavior, to actively seek for the relationship between mathematical knowledge and physical knowledge, and then slowly affect the objective level of students, and then in mathematics and physics performance, and (3) applying mathematical thinking to physics learning can improve the efficiency of learning physics. Use mathematical knowledge of trigonometry to solve the force analysis problem of physical movement. This shows that math scores play a very important role in physics scores. Remind us that in the process of teaching, we should pay attention to the integration of mathematical ideas into physics learning, and help students to learn physics knowledge better with mathematical ideas.

Keywords: Achievement, Correlation, Mathematics, Physics

INTRODUCTION

Physics and mathematics are the two most closely related natural rudimentary subjects (Kareem & Hussin, 2013; Kent, 2008). In the study of physics, often need to rely on mathematical rigorous reasoning and argumentation, but also need to use a variety of mathematical methods for investigation, reasoning, calculus, test, discussion, but students often appear in these difficulties (Yopp, 2011). One of the most common situations is that many students can list the equations according to the physical situation and physical laws but can't solve the equations (Papadopoulos, 2019; Tam et al., 2021). On further deepening of study of physics, the application of mathematics will become more and more important, if in the middle school stage better cultivate this awareness, exercise applied mathematics knowledge to strengthen the ability of physics problem solving, also must lay a solid foundation for the future study (Högskola & Turner, 2020).

In practical teaching, high school students often have learning obstacles in the process of physics learning because they cannot transfer mathematical knowledge to physics. Specifically: first, From the student’s perspective, physical knowledge mostly not easy for students to understand is...
often closely related to mathematical knowledge, and it is difficult for students to flexibly apply mathematical knowledge to physics learning, whether at the level of ideology or in the level of concrete operation (Putra & Heriyanto, 2020; Sari, Sutarto, Mudakir, Supeno, & Budiarsa, 2020). Take the knowledge in the mechanics chapter as an example, the scoring rate of students is always very low (Wang, Lee, Lin, Mi, & Yang, 2021). Carefully analysis shows that in many cases, students do not grasp the physical knowledge, for example, students know the rule of the parallelogram and can correctly carry out orthogonal decomposition on the horizontal plane. However, when the problem situation becomes a force decomposition on an inclined plane, many students start to get confused. The main reason for the difficulty is that the knowledge of trigonometry is not good enough. In addition, the expression of geometric knowledge is also difficult, such as the correct transformation of the trajectory of the electron movement, and the process of the motion state of the object is not clear. So if researchers can solve this problem, students will have a great improvement in physics learning.

Second, from the perspective of teaching, physics teachers do not pay enough attention to the mathematics knowledge involved in teaching and lack of systematic summary. Physics teachers always think that students have learned similar knowledge in mathematics class, and overestimate the ability of students to transfer knowledge. In fact, many students often forget some basic mathematical knowledge, so they can not apply it to physics very smoothly (Ayalon, 2019; Middleton, Cai, & Hwang, 2015; Pereira, Huang, Chen, Hermita, & Tamur, 2020). On the contrary, if a certain amount of effort is to break through the students' difficulties in related mathematics, it may play a better effect. In addition, in some new class teaching, teachers often ignore some relatively difficult derivation problems involving applied mathematical knowledge, such as those related to calculus. Some teachers directly give up this part of knowledge, so that students actually just remember the conclusion, but do not really understand the logic and connotation (Juandi, Tamur, Adem, & Pereira, 2020; Stapleton, 2011).

Third, from the perspective of the examination paper, the ability to apply mathematical knowledge to solve physical problems has become very necessary in the process of solving the college entrance examination problems, especially in solving relatively comprehensive physical problems are particularly prominent. In addition, this ability is also indispensable in the higher stage of physics learning, so that students can realize the importance of this ability earlier, which is also very beneficial to the lifelong learning and development of students. In fact, in various cases, many physical problems can be transformed into mathematical problems, such as the critical problem in physics, and the extremum problem in mathematics in many cases. By looking at the problem from different Angles, our solutions will be more flexible (Crespo & Harper, 2020).

If researchers can explain the correlation between mathematical results and physical results from the perspective of data, researchers can more clearly use mathematical knowledge to solve the physical knowledge in the teaching or learning process consciously and strengthen the organic correlation between the two. This is of great practical significance to teachers' lesson preparation or students' independent learning, to avoid thinking stuck in a certain subject. By drawing lessons from the way of thinking of different disciplines will also be of great help to our problem-solving ability and application ability (Pereira, Wijaya, Zhou, & Purnama, 2021; Pereira, Tan, Li, & Purnama, 2020; Xu, Wu, & Lang, 2020).

To better study, the correlation between math scores and physics scores, this paper, under the guidance of education experts, take the final exam scores of grade 12 students in the first semester of a high school as the research object (Barham, 2012; Chen, Zhao, & Hwang, 2021). The
overall performance of this school in the local area is at an average level, and the foundation of mathematics and physics is relatively good. From this perspective, their overall performance in general and has completion mathematics and physics are two courses of study. Students for mathematics and physics between the subjects of correlation, complementarity, and so on has a deep experience. By talking to them, you can also understand their thoughts instinctively.

Compared with previous studies, the innovation of this study is reflected in two things. First, it will choose 30 class's and grade's students (364 students) according to the average math scores, from big to small order, and then select the rank in the class as A group 1, 2, remember as A1, A2, ranked in the 15th and the 16th class as group B, B1, B2, ranked in the 29th, the 30th class as group C, for C1 and C2. Taking different levels of math scores as the standard to examine the relationship between math scores and physics scores has the characteristics of diversity and representativeness, and the results obtained are more convincing. Secondly, it makes a comparative analysis of the difference between the mathematical mean and the physical mean. Since the mean can represent the overall level of a class. The changing trend of the mean can better reflect the overall difference of the mathematical and physical scores at different levels, and more reliable conclusions can be drawn from the overall level of the scores.

According to the introduction and observation, the researcher formulation that, 1. Objectively, is there a linear relationship between math scores and physics scores? And 2. Subjectively, do students think there is a relationship between math scores and physics scores?

METHOD

The research method used in this paper is a mixed-method, include literature analysis, statistical analysis, and interview method. After finishing the mid-term examination of the first semester of senior high school grade 12, the researchers collected students' Mathematics and physics scores from the school as the research data. After finishing the data in Excel, SPSS 22.0 software was used for statistical analysis.

Literature analysis is the basis of scientific research. By collecting and sorting out existing research and findings, researchers can find out the progress and shortcomings of relevant research. At this stage, researchers found that many studies objectively analyzed the influence of certain factors on math learning or physics learning from the perspective of gender and region, analyzed the relationship between math achievement and physics achievement, and came to the conclusion that there was a relationship between math and physics discipline, and that math achievement could affect physics achievement. However, these studies involved external variables and did not start from the data of mathematical and physical scores. The focus of this study was on the objectivity and universality of the data. Statistical analysis can explain the objective reality reflected in the real world from the perspective of data itself, which is objective. Statistical analysis includes a comprehensive range of methods, including basic statistical data, normal test, linear test, regression analysis, non-parametric test, etc. In addition, the accuracy and speed of calculation of SPSS 22.0 are faster and more convenient than those of manual calculation. The interview method emphasizes that the relationship between variables should be explained from the subjective feelings of the interviews, or the way of thinking should be explored from people's subjective experience and that learners can flexibly apply different knowledge to different aspects after learning different knowledge through their understanding and divergence. For example, Newton thought about the reason why apples fall to the ground naturally from the natural phenomenon, and thus discovered
the universal gravitation and pushed out the universal gravitation formula, and applied it to physics and astronomy.

For two arbitrary variables, if there is some correlation between them, what methods are used to determine their correlation? Based on this question, this paper chooses to use Alpha coefficient analysis to analyze the reliability of the data, and then uses SPSS 22.0 software to analyze the basic statistics, normality test, paired sample t-test of the data, and draws the scatter diagram of the math and physics scores of each class to observe whether they are linearly correlated. If there is a linear correlation, then it means that math grades affect physics grades. The innovation of the research method lies in the reliability of the analysis data and the comprehensive analysis and test of the relationship between the mathematics scores and the physics scores of high, middle, and ordinary students, which makes the conclusion more scientific and effective.

According to their math scores, researchers divided the students into 12th grades: excellent (top 27%), medium (middle 46%), and average (bottom 27%), and then selected one student from these 12th grades as the interviews. Finally, grade 12 students were randomly selected for the interview. Figure 1 shows the detailed process of the study.

![Figure 1. Research framework](image)

Literature analysis and statistical analysis are commonly used in the process of data research (Brown, 2017; Chen et al., 2021; Puteh, Hanafi, & Azman, 2017). Based on them, combined with SPSS 22.0 software, a comprehensive data analysis was conducted to explore the correlation between math scores and physics scores from multiple perspectives. Then, some students were interviewed to verify the results of data analysis from the perspective of emotion.

**FINDINGS**

**Reliability analysis**

Before the relevant research, the reliability analysis, namely reliability analysis, was carried out on the math and physics scores of the six classes. The method chosen in this paper is Alpha coefficient analysis, and Cronbach's Alpha coefficient of 6 classes is obtained. The analysis results are shown in Table 1.
Table 1. Cronbach's coefficient

| Score            | N  | Coefficient | Level |
|------------------|----|-------------|-------|
| MA1 & PA1        | 63 | .751        | Good  |
| MA2 & PA2        | 56 | .729        | Good  |
| MB1 & PB1        | 61 | .769        | Good  |
| MB2 & PB2        | 63 | .717        | Good  |
| MC1 & PC1        | 60 | .730        | Good  |
| MC2 & PC2        | 61 | .719        | Good  |

In terms of reliability, we can see from Table 1 that the reliability of the selected 6 classes all reached the level of GOOD. It shows that the math and physics scores of these six classes have good reliability, which indicates that the data has research value.

Normal Test

The normal distribution is a kind of probability distribution of continuous random variables, characterized by a left-right symmetrical shape with high in the middle and low at both ends. The result of the course examination reflects the performance of students' course level in test questions and test environment, and the factors that affect the result of students' course foundation, value-added learning results, test contents, and test environment can be regarded as random variables. Therefore, educators generally believe that the result of the course examination should conform to the normal distribution. Table 2 shows the normality test results of 6 classes.

Table 2. Normality Test Results

| Model  | Sig.   | Decision        | Conclusion |
|--------|--------|-----------------|------------|
| MA1    | 0.793  | Ho is not rejected | Normal    |
| PA2    | 0.873  | Ho is not rejected | Normal    |
| MA2    | 0.917  | Ho is not rejected | Normal    |
| PA2    | 0.723  | Ho is not rejected | Normal    |
| MB1    | 0.613  | Ho is not rejected | Normal    |
| PB1    | 0.658  | Ho is not rejected | Normal    |
| MB2    | 0.914  | Ho is not rejected | Normal    |
| PB2    | 0.524  | Ho is not rejected | Normal    |
| MC1    | 0.606  | Ho is not rejected | Normal    |
| PC1    | 0.639  | Ho is not rejected | Normal    |
| MC2    | 0.62   | Ho is not rejected | Normal    |
| PC2    | 0.682  | Ho is not rejected | Normal    |

As can be seen from Table 2, the significance probability of the math and physics scores of the six selected classes is greater than 0.05, which conforms to the normal distribution, indicating that the scores of these classes are integrated and representative, which is in line with the significance of statistical research.

Basic Statistics

Next, we analyzed the basic statistical data of the six classes, such as the average score, standard deviation, and standard error of the mean, to see the performance of these data in terms of stability. The results are shown in Table 3.
As can be seen from Table 3, the math and physics scores of the 6 selected classes show three different levels of their mathematical and physical mean values, on the other hand, the standard deviation and standard error of the mean values are close. This shows that in different levels of classes and different teaching environments, students' math and physics scores have good stability on the overall level. These stable data are helpful for us to eliminate experimental errors caused by some objective factors and unstable factors and help us to draw conclusions that are more consistent with the facts.

**Difference of Mean Values between Classes**

To further examine the relationship between mathematical and physical achievements at the mean level, we drew the mean as a separate line graph and used a black line segment to represent the distance between the mathematical and physical means. The results are shown in Figure 2.

**Figure 2. A line chart of the mean value**
Figure 2 is a line chart of the average scores of math and physics scores of 6 classes. By figure 1, you can directly observe, when the class average math scores are higher the average score of physics are also higher, and the mathematical average between each class as math and physics of average gap becomes smaller and smaller, it is explained in average grade level in math and physics performance are closely linked. Education experts and statistics experts believe that the distance of group A in math and physics performance is greater than that of group B, group C reason is that the full marks are 150 points in math, physics performance full marks are 110, while students in math and physics have achieved very good results, but because of their total score is not the same, so the average level is not the same, so when students get high scores in both subjects, the difference between group A and group B is larger than that between-group C. However, from the perspective of overall scores, the higher the mean value of math scores, the higher will be the mean value of physics scores, so it can be considered that there is a close relationship between math scores and physics scores.

Correlation Coefficient

From the above analysis, it can be seen that math scores and physics scores have the characteristics of normality and stability, and there is a close relationship between math scores and physics scores. In order to describe the strength of this connection, the paired sample t-test was carried out on the results of these six classes to obtain the correlation coefficient between the math scores and the physics scores of each class. The results are shown in Table 4.

| N  | Correlation coefficient | Sig. |
|----|------------------------|------|
| 1  | MA1 & PA1              | .649 | .000 |
| 2  | MA2 & PA2              | .624 | .000 |
| 3  | MB1 & PB1              | .607 | .000 |
| 4  | MB2 & PB2              | .570 | .000 |
| 5  | MC1 & PC1              | .587 | .000 |
| 6  | MC2 & PC2              | .575 | .000 |

According to the correlation coefficient in Table 5, the correlation coefficient of the first three classes is all greater than 0.6, and the correlation coefficient of the next three classes is also close to 0.6, indicating that there is a strong positive linear relationship between math scores and physics scores. For example, for the row of MA1 & PA1, if the student's math score is 100, then the student's physics score can reach 100*0.649=64.9. Moreover, their significance probabilities are all 0.00, which is less than 0.05, indicating that there is a very good correlation between the math scores and the physics scores of these six classes, which are of statistical significance.

In order to describe the strong or weak relationship between the correlation coefficient and variables, we give Table 5 as a reference.

Table 5 Relationship between correlation coefficient and two variables

| Correlation Coefficient | Degree of correlation |
|-------------------------|-----------------------|
| r = 1                   | Complete positive correlation |
| 0.7 < |r| < 1                | Highly correlated |
| 0.4 < |r| < 0.7               | Significant correlation |
| 0 < |r| < 0.4                | Lowly related |
| r = -1                  | Complete negative correlation |
| r = 0                   | No correlation |
Scatter Plot

Figure 2 is the scatter diagram of the six classes, from which we can more intuitively see the linear relationship between math scores and physics scores, which intuitively confirms our conclusion. Mathematics score has no independent variable, while physics score is the dependent variable.

![Scatter Plot](image)

Through the above data analysis, objectively, it can be shown that there is a positive linear relationship between math scores and physics scores. In general, the better you do in math, the higher you do in physics.

Personal Interviews

Through the data statistical analysis, we concluded that the performance of mathematics can affect the performance of physics from the objective level, which is a technical test method based on objective facts. As far as students' subjective feelings are concerned, an important factor that affects their academic performance is emotion. Interest is the best teacher, but also the long-term motivation of learning because students know how to learn mathematics is conducive to promote the study of physics, so invest more time will not feel tired, the results of the two subjects are also easy to improve. Therefore, such a point of view has formed a psychological implication in the mind of students. So for the students themselves, do they agree that learning math is helpful for the study of physics?

Based on the consideration of emotional factors, with the guidance and help of two education experts, we carefully designed six questions and selected one student from A1, B1, and C1 to answer them. The interview questions and answers are there in Table 6.
Table 6. Students’ Statements

| Questions                                                                 | No. | Answers                                                                                                                                                                                                                          |
|---------------------------------------------------------------------------|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Do you think it important to learn maths well for physics?                | 1   | Yes, many methods of mathematics can be used in physics learning, physics drawing skills are also very helpful to solve mathematical problems, there are a lot of similarities between them. |
|                                                                           | 2   | Yes, most of the students who did well in math did well in physics. Teachers often say that mathematical methods can be used in physics learning, although I am not good at using them, I agree with this point of view. |
|                                                                           | 3   | Yes, there are a lot of physics problems I have seen in the process of learning mathematics, such as simplifying algebraic expressions, calculating angles and distance problems, and math problems often appear and physics-related background. |
| Does the physics teacher supplement math knowledge in class?             | 1   | It is often emphasized that the teacher will show us the simple and clear calculation process, and explain how to think from a mathematical point of view when solving the problems. |
|                                                                           | 2   | Occasionally, in the consolidation of knowledge, the teacher will be physics exercises and math exercises together to review, deepen our impression.                                                                                       |
|                                                                           | 3   | Generally speaking, the calculation method of mathematics is introduced when the calculation is simplified, and the other time is not too much.                                                                                     |
| Do you have difficulty learning physics because of your poor math foundation? | 1   | Often appeared in the past such a problem, a lot of physics questions in mathematics have seen, but just can't remember how to do, now the teacher said more feel can understand.                                                   |
|                                                                           | 2   | The difficulty is mainly in the drawing. The force decomposition needs a Cartesian coordinate system, and the coordinates of the center of the circle, the radius, and the motion time of the electron trajectory are also closely related to mathematics. All these are my difficulties. |
|                                                                           | 3   | Because of my poor mathematical foundation, I often failed to find out the equivalence relationship in the physics problems or did not know how to make a variable substitution.                                              |
| What mathematical knowledge do you think is closely related to physical knowledge? | 1   | Solution of triangles, trigonometric functions, and other computationally large knowledge                                                                                                                                       |
|                                                                           | 2   | Knowledge of systems of equations, inequalities, etc. related to the relationship between variables                                                                                                                            |
|                                                                           | 3   | In terms of drawing, mathematics emphasizes the combination of numbers and shapes, and physics also needs to find out the relationship between problems and variables, so it is often necessary to draw to express logic clearly. |
| In which knowledge points do you want the physics teacher to strengthen the use of mathematics knowledge? | 1   | I want to learn more about trigonometric functions. There are too many trigonometric functions involved in physics problems, and I often test them in big questions. I hope I can learn more about trigonometric functions. |
|                                                                           | 2   | When explaining the calculation, I should explain the calculation process more slowly. Many complicated simplification processes were quickly finished by the teacher, and I had not yet had time to understand the principle. In addition, it is best to add some examples. |
|                                                                           | 3   | I hope that teachers can teach more drawing skills or use graphics to express the relationship between variables. In terms of object movement trajectory, they can also combine more knowledge of functions to deepen their impression and understanding. |
| Do you believe that if you do well in math, you can do better in physics? | 1   | Of course, if I were good at math, I would get more than this score in physics                                                                                                                                                     |
|                                                                           | 2   | I believe that good mathematics can not only improve the performance of physics but also play a great role in the study of other subjects and thinking.                                                                                                                                 |
|                                                                           | 3   | I agree with this point, most of the people who do well in math, also do well in physics, but the students who do well in physics, do not necessarily do well in math. Teachers often tell us to strengthen the study of math, math scores up, and then learn other subjects will not be difficult. |

As can be seen from the answers in Table 6, in the cognition of the students, they all agree
that learning mathematics knowledge plays a great role in promoting the learning of physics knowledge. They also want teachers to strengthen the use of mathematics in physics learning, especially calculation and drawing skills, as well as ways of finding relationships between variables. Due to the need to model the problem when solving the physical problem, and then use special methods to solve the problem, this process often uses mathematical ideas or mathematical methods. Therefore, students show great enthusiasm for the application of mathematical knowledge in physics study. From their answers can see, in the student impression if a student got very good in math, so will his physical performance better, the ubiquitous fact also psychological form a hint of the students, also suggests that the concept of the students, mathematics can indeed have a positive impact in physics learning.

DISCUSSION
From the results of data analysis and students' subjective thinking, there is sufficient reason to believe that there is a close relationship between math and physics scores. Concluded that, in terms of reliability of the selected 6 classes all reached the category of good. According to the correlation coefficient, the correlation coefficient of the first three classes is all greater than 0.6, and the correlation coefficient of the next three classes is also close to 0.6, indicating that there is a strong positive linear relationship between math scores and physics scores. For example, for the row of MA1 & PA1, if the student's math score is 100, then the student's physics score can reach 100*0.649=64.9. Moreover, their significant probabilities are all 0.00, which is less than 0.05, indicating that there is a very good correlation between the math scores and the physics scores of these six classes, which are of statistical significance.

Based on the above results, the relationship between math and physics results is very significant. These results are supported by some researchers who oppose them. For example, Barham and Chen said that students who do well in math also do well in physics, because the methods used to solve math problems can be used to solve physics problems (Barham, 2012; Chen et al., 2021). According to the previous research results, which are also supported by the interview results of some students mentioned above, students believe that the methods of learning mathematics and learning physics are very similar, because if they can perfectly understand the steps of solving mathematical problems, then students' physics performance will be considerably improved.

CONCLUSION
The mathematical and physical scores of 6 classes obtained by stratified sampling show good results in reliability analysis, normality test, paired sample t-test, and scatter chart, indicating that there is an obvious positive correlation between the mathematical and physical scores. In the process of interviewing students, they can tell the corresponding relationship between mathematics and physics and realize that there are many similarities between mathematical knowledge and physics knowledge. The research results suggest that we should clarify the positive role of mathematics in promoting physics and appropriately strengthen the application of mathematical methods in the physics learning process. Therefore, objectively, there is a positive linear relationship between math achievement and physics achievement. If it can improve students' math achievement, it will also be of great help to students' physics achievement. On the subjective level, students accept the view that the performance of mathematics can promote the performance of physics, and they also hope
to learn more ways to use mathematics knowledge to solve physics problems; and (3) Applying mathematical thinking to physics learning based on enhancing mathematical understanding can improve the efficiency of physics learning.

First, this paper only selects part of the classes in a middle school as the research object. For other classes in this school or other schools, the correlation between their math scores and physics scores remains to be further studied. Secondly, are there any other subjects that have a certain impact on the correlation between math and physics scores? That is to say, whether the performance of other subjects will have a more obvious effect on the improvement of physics performance? In other words, the improvement of physics scores is not only related to math scores, but also in other subjects that may play a significant role, which is not discussed in this paper. Researchers look forward to furthering their studies.

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**AUTHORS CONTRIBUTION**

| Author                | Contribution                                                                 |
|-----------------------|------------------------------------------------------------------------------|
| Jihe Chen             | Complete the writing of the article                                          |
| Jerito Pereira        | Corresponding Author. Revise the paper, including first, 3rd, 4th, 5th, and 6th |
| Xinxin Li             | Complete data collection and analysis                                        |
| Ying Zhou             | Provide writing ideas and writing guidance                                   |
| Maximus Tamur and     | Check translations, references and recheck Grammarly                         |
| Syaharuddin           |                                                                               |