



Beyond Intelligence: The Power of Grit in Achieving Cognitive Excellence Achievement in Chemistry for Sustainable Education

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Abstract

Academic achievement is often associated with cognitive ability; however, non-cognitive skills, such as grit, also play an important role in determining learning outcomes. Chemistry is a challenging subject because of the many abstract concepts that require perseverance and dedication to comprehend. This study aimed to examine the relationship between grit and students' cognitive achievement in chemistry learning at the secondary school level, as well as to evaluate the extent to which grit affects learning success. The method used was quantitative, with a survey approach of 200 students in class X in Pekanbaru, Indonesia. The research instruments consisted of a talent questionnaire and a multiple-choice test to measure cognitive chemistry achievement. The data were analyzed using the Pearson product-moment correlation technique after performing prerequisite tests, including normality and homogeneity tests. The results of the analysis showed a significant positive correlation between grit and cognitive achievement ($p = 0.001 < 0.05$), with a correlation coefficient of 0.234, which is classified as low. These findings indicate that students with higher grit levels tend to have better cognitive performance in chemistry learning, although other factors also play roles. In addition, this study is in line with the Sustainable Development Goal concerning Quality Education, particularly through its focus on the role of non-cognitive skills in learning.

Keywords: Academic success, Chemistry education, Cognitive achievement, Grit

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INTRODUCTION

Among the various non-cognitive abilities, academic grit has been recognized as an important factor in academic achievement (Duckworth et al., 2007; Datu & Fong, 2018). Grit refers to long-term passion and perseverance in achieving goals, as well as the ability to stay consistent and rise from failure (Muhibbin & Wulandari, 2021). The two main dimensions are consistency of interest and perseverance in effort, both of which play important roles in achieving academic success (Datu et al., 2018; Singh & Chukkali, 2021; Xiao et al., 2023).

Various studies have shown that *grit* is positively correlated with academic achievement at both the high school and college levels (Fong & Kim, 2021a; Halperin & Eldar Regev, 2021; Fernández-Martín et al., 2020; Sari & Royanto, 2019). Students with high *grit* tend to be more

resistant to learning pressure, focus on long-term goals, and cope with academic challenges (Bazelais et al., 2018; Helm & Rosenegger, 2021). In the context of education, *grit* acts as a coping mechanism that allows students to survive learning difficulties, especially in challenging subjects such as chemistry (Postigo et al., 2020; Hodge et al., 2018).

Theoretically, *grit* affects achievement because persistent students will continue to strive despite failure, do not give up easily, and remain focused on their academic goals (Duckworth & Quinn, 2009). This perseverance supports the process of repetitive learning, in-depth exploration of the material, and development of better learning strategies. In contrast, students with *low grit* tend to give up easily when faced with difficulties, lose focus on long-term goals, and lack academic endurance. Some studies have shown that low *grit* correlates with low

achievement, as students with low *grit* show unstable motivation, tend to avoid challenges, and have higher levels of mental and emotional fatigue (Holdan et al., 2018; Christopoulou et al., 2018; Uribe-Moreno et al., 2024).

In addition, *grit* has been shown to mediate the relationship between motivational factors and learning outcomes, making it an important determinant of sustainable cognitive achievement (Chen et al., 2024; Martoyo & Lindawati, 2023). Therefore, increasing students' *grit* is an important strategy for helping them cope with academic pressure and achieve optimal achievement.

Unfortunately, research on *grit* in Indonesia is still limited, mostly descriptive, and has not focused on the empirical correlation between *grit* and learning achievement, especially in the context of chemistry learning. These limitations show that there are research gaps that need to be filled so that policymaking and the development of diligence-based learning strategies have a strong scientific basis.

This study aligns with the goals of the Sustainable Development Goals (SDGs), particularly SDG 4: Quality Education, which promotes inclusive, equitable, and lifelong learning for all (Kiopi & Voulvoulis, 2019). Understanding *grit* as a non-cognitive factor that supports academic resilience is crucial, especially in complex subjects like chemistry, where sustained effort and perseverance are key to success.

This study aimed to empirically examine the relationship between *grit* (academic persistence) and students' cognitive achievement in chemistry learning at the high school level. The research results are expected to contribute to designing educational interventions that

encourage students' perseverance and motivation to improve their learning outcomes.

METHOD

This study used a quantitative approach with a survey method to test the relationship between *grit* and students' cognitive achievement in chemistry learning. The sample consisted of 200 students in Class X in Pekanbaru, Indonesia, who were selected through *cluster random sampling* techniques (Ozturk et al., 2023). This study did not use interviews, and all data were collected in writing through questionnaires and tests.

The research instruments included:

- The Grit questionnaire consists of 12 items measured on a 5-point Likert scale (SS–STS). This questionnaire covers three main aspects.
 1. Learning consistency (the ability to maintain focus in the learning process),
 2. Hard work (willingness to work hard in facing challenges),
 3. Determination to learn (determination to achieve academic goals despite failure).
- The Cognitive Achievement Test consists of 12 multiple-choice questions based on the chemistry curriculum for class X.

The instrument was validated in terms of content through expert assessment and empirically through validity tests, and tested for reliability using Cronbach's alpha. The results are presented in Table 1. Data analysis was carried out using the Pearson product-moment correlation technique with the help of SPSS 26.0 software. *Grit* was an independent variable, while cognitive achievement was a dependent variable.

Table 1. Instrument validity and reliability test results

Instruments	Number of Items	Validity (Empirical)	Cronbach's Alpha	Finding
Grit Questionnaire	12	All items are valid	0,842	Reliabel
Cognitive Performance Test	12	All items are valid	0,840	Reliabel

RESULT AND DISCUSSION

Based on the results of data collection that has been carried out on 200 students through the

distribution of questionnaires and questions through Google form links, the results obtained after being processed using SPSS 26.0 for Windows are as follows.

Table 2. Descriptive statistical test results

Variable	N	Min	Max	Mean	SD
Grit	200	12	60	37	8.937
Cognitive Achievement	200	0	120	85.5	32.589

Based on Table 1, the descriptive statistical test shows that the total number of research subjects is 200 students. For the grit variable, the minimum value is 12, and the maximum value is 60, with an average of 37. The grit variable has a standard deviation of 8.937. Meanwhile, for the

student achievement variable, it is known that the minimum score is zero, and the maximum score is 120, with an average of 85.5 and a standard deviation from the cognitive achievement variable of 32.589.

Table 3. Distribution of grit categorization

No	Interval	Frequency	Percent	Category
1	42-60	62	31%	High
2	21-41	133	66,5%	Medium
3	12-20	5	2,5%	Low
Total		200	100%	

Table 3 shows that 31% or as many as 62 students get high grit. The most dominant category is moderate, namely 66.5% or 133 students. And 2.5% or five students get low grit.

From the results above, it can be concluded that the grit owned by students is included in the medium category.

Table 4. Distribution of cognitive achievement categorization

No	Interval	Frequency	Percent	Category
1	82-120	121	60,5%	High
2	41-81	52	26%	Medium
3	0-40	27	13,5%	Low
Total		200	100%	

Table 4 contains data on student cognitive achievement. Based on the table, the results are 60.5% or 121 students who get the high cognitive achievement category, and the cognitive achievement category is in the medium category, which is equivalent to 26% of 52 students.

Meanwhile, for the low category, it was 13.5% or 27 students. From the table, it can be concluded that students' cognitive achievement is categorized as high learning achievement because it has the largest percentage.

Table 5. Normality test results

Variable	Kolmogorov-Smirnov	
	α	Sig. (2-tailed)
Grit with Cognitive Achievement	0.05	0.200

Based on the table above, the results of the Asymp value were obtained. Test normality sig. The grit variable with cognitive achievement obtained a value of $0.200 > 0.05$, so based on the decision-making of the Kolmogorov-Smirnov normality test, the data from the grit variable and

cognitive achievement were concluded to be normally distributed.

The homogeneity test in this study uses Levene's statistic analysis technique. The results of the grit variable homogeneity test with students' cognitive achievement can be seen in the following Table 6.

Table 6. Grit Homogeneity test results and academic achievement

Variable	Levene Statistics	
	α	Sig. (2-tailed)
Grit with Cognitive Achievement	0,05	0,184

Table 5 contains the results of the homogeneity test, which shows that the significance value obtained by the grit variable for cognitive achievement is 0.184. The conclusion obtained was that the grit data with students' cognitive achievement was distributed homogeneously because the significance value was greater than 0.05 (α).

The next prerequisite test of analysis is a linearity test that is useful to see if there is a correlation between grit and students' cognitive achievement that forms a straight line. The results of the linearity test in this study are listed in Table 7.

Table 7. Linearity test results

Variable	Deviation of Linearity	
	α	Sig. (2-tailed)
Grit with cognitive achievement	0,001	0,521

Table 6 shows that the linearity test of grit variables with cognitive achievement obtained a significance value (Sig.) of linearity deviation of 0.521. Therefore, it can be concluded that perseverance and cognitive achievement are linearly related.

The three prerequisite analysis tests that have been carried out show that the research data is distributed normally, homogeneously, and linearly related. Therefore, hypothesis testing in the form of a correlation test can be carried out.

To test the research hypothesis by using the Pearson Product-Moment correlation technique to analyze the correlation/relationship between grit and students' cognitive achievement. As for its implementation, the testing of this hypothesis was carried out with the help of SPSS Statistics 26. Table 8 shows the results of testing the hypothesis of the relationship between grit variables and cognitive achievement.

Table 8. Correlation test results

Correlations			
Grit		Grit	Cognitive achievement
Cognitive achievement	Pearson Correlation	1	0.234**
	Sig. (2-tailed)		0.001
	N	200	200
	Pearson Correlation	0.234**	1
	Sig. (2-tailed)	0.001	
	N	200	200

** . Correlation is significant at the 0.01 level (2-tailed).

The basic reference in decision-making in the Pearson correlation test used is to compare sig. (2-tailed) with a value of $\alpha = 0.05$. If the acquisition of a significance value is $< \alpha$, it can be concluded that there is a correlation or relationship between the two variables tested. Based on Table 7 above, it can be seen that sig. (2-tailed) is equal to 0.001 < 0.05 , so it can be concluded that there is a correlation or relationship between grit and cognitive achievement, and the correlation coefficient has

no negative sign, so the correlation is positive. This means that the higher the student's fortitude, the higher his cognitive achievement, and vice versa.

The importance of chemistry in general education has been recognized globally, making it one of the most significant subjects taught in schools today (Bochet, 2023; Ejidike & Oyelana, 2015; Sevian & Bulte, 2015). Chemistry Education is more than just an accumulation of information and data. Everything with mass and

spatial dwellings is referred to as matter. Given that it connects the natural sciences—such as physics, geology, and biology—chemistry is often referred to as a core science (Dyachenko et al., 2024; W. Jane & W. Florence, 2022; Zheng, 2017). Chemistry classes should be an important resource for understanding natural phenomena and environmental phenomena. Students argue that by applying the chemical information they get in class, they should be able to understand the difficulties they face in their daily lives and find solutions (Habig et al., 2018; Lindstrom & Middlecamp, 2017). Students need to experience their education in a variety of life contexts and develop a coherent mental plan related to the subject matter (Giraldo-García & Chang, 2023; Havsteen-Franklin et al., 2023). Nevertheless, despite the direct connection of chemistry to everyday life, many students continue to see it as an abstract and difficult subject that is unrelated to life (Mennani et al., 2023; Sausan et al., 2020). For chemistry classes to no longer be seen as abstract and difficult, students must look at how knowledge of chemicals can be applied in real-world situations. Students become more curious when the subject is properly connected to examples from real life (González-Peño et al., 2021; Kibga et al., 2021; Mebert et al., 2020). Providing students with practical knowledge that they can apply in their daily lives can help them understand the relationship between chemistry and everyday life. As a result, they may prefer to apply their understanding of chemistry to the interpretation of the facts they encounter (Gkitzia et al., 2011; Stammes et al., 2023).

Academic achievement in students is influenced by fortitude, a non-cognitive component. To achieve long-term goals, perseverance involves endurance and joy (Avanesian et al., 2022; Teimouri et al., 2022). Some of the obstacles students face during their education include pressure, learning difficulties, learning helplessness, and workload (Ainscough et al., 2018; Al Sarairah, 2024; Alshammari et al., 2023; EL Alaoui et al., 2021). In theory, scholars who study fortitude may agree that fortitude promotes better academic performance. Grit motivates students to participate in academic activities that result in higher academic outcomes because academic success is a long-term goal full of problems that require time commitment and self-organization to overcome. Provide evidence of a mutually reinforcing relationship between the perseverance and academic success components, and clarify the sociocognitive

characteristics of perseverance (Helm & Rosenegger, 2021c; Hwang et al., 2018; Lam & Zhou, 2019a; Xu et al., 2023). Findings Martin et al. (2022) had a similar sentiment when they determined that there was a correlation between the academic progress of students and Grit, based on correlation and regression analysis. Grit has a great influence on achievement and success. People are born with a certain number of talents or competencies. These skills, however, are not established and can develop directly proportional to the presence. Grit is a combination of passion and work. On the positive side, research continues to show that Grit accurately predicts students' GPAs (Fong & Kim, 2021c). Therefore, grit is considered very important to remain consistent in achieving long-term goals and can motivate them to continue to strive to face challenges in learning and succeed in their studies.

The results of the data analysis described above illustrate that there is a positive relationship between grit and students' cognitive achievement in high school. The higher the student's perseverance, the higher their cognitive achievement in learning. Based on research, students who have high grit will be more successful in academics and graduate well. This is because a person who has a high level of grit will focus on their long-term goals and be able to survive any challenges or difficulties they face. There is some evidence, based on research Woodward et al. (2024), that grit construction can play a major role in a student's greater academic success. This further shows the importance of perseverance in the learning process. When a person experiences their difficulties, worries, or important circumstances, fortitude can also be defined as the passion and desire to achieve long-term goals, despite the pain and adversity. Grit can also be a dynamic personality strength (Bhullar et al., 2020; Kozlova et al., 2024). Grit generally refers to the capacity to stay engaged and exert effort on long tasks.

The study found a significant positive correlation between grit and students' cognitive achievement in chemistry, with a Sig. 2-tailed value of $0.001 < 0.05$ and a correlation coefficient of 0.234. This indicates that students with higher levels of grit tend to achieve better academic results (Yan et al., 2023). Although the correlation is low, similar findings have been reported in previous studies (Bazelais et al., 2018; Lam & Zhou, 2019).

Grit enhances academic performance because persistent students are less likely to give up, remain focused on long-term goals, and are intrinsically motivated—factors that are essential for mastering complex concepts in chemistry (Postigo et al., 2020; Hodge et al., 2018). In this context, grit involves three key aspects: (1) learning consistency, (2) perseverance, and (3) learning determination.

Importantly, grit is not innate but can be developed through overcoming challenges, receiving social support, engaging in disciplined study environments, and practicing reflection (Duckworth et al., 2007; Christopoulou et al., 2018). Thus, fostering grit is a strategic approach to improving students' academic resilience, particularly in demanding subjects like chemistry. This aligns with the Sustainable Development Goals (SDGs), especially SDG 4: Quality Education, which emphasizes inclusive and equitable education and the development of learners' full potential. Research has shown that enhancing non-cognitive traits such as grit contributes to academic achievement by promoting sustained effort, perseverance, and goal-oriented behaviors (Credé et al., 2017; Tang et al., 2019), which are critical for improving cognitive performance and long-term educational outcomes.

CONCLUSION

This study investigated the relationship between grit and cognitive achievement in chemistry learning. The results showed a significant but low positive correlation, indicating that students with higher grit tend to perform better academically. Beyond intellectual ability, grit and resilience are critical in mastering complex chemistry concepts. In a challenging subject such as chemistry, grit helps students stay motivated, committed to long-term goals, and willing to overcome adversity. Its key components, learning consistency, hard work, and determination to learn, support continued learning efforts and academic success. These findings highlight the importance of non-cognitive traits such as grit in education. Educators must design strategies that foster grit, discipline, and motivation. Theoretically, this study supports grit as a predictor of academic success in chemistry; practically, it emphasizes the need to foster students' grit through a supportive learning environment. However, the low correlation suggests that other factors also contribute to student achievement. Additionally,

this study not only contributes to the science education literature but also supports SDG 4 (Quality Education) by highlighting the importance of building resilience to enhance academic persistence. Strengthening non-cognitive traits such as resilience can foster resilient learners who are better prepared to achieve long-term educational goals.

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