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Understanding High School Mathematics Learning Through Grit and Achievement Goals: An Empirical Study

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Abstract

This study examined the associations among grit, achievement goal orientations, and mathematics achievement among Grade 10 students in a private high school in Quanzhou, Fujian Province, China. A total of 256 students participated in the study, and 248 valid responses were included in the analysis. Grit was measured through perseverance of effort and consistency of interests. Achievement goal orientations included mastery goals, performance approach goals, and performance avoidance goals. Mathematics achievement was assessed using students' formal school test scores. Multiple regression analysis and hierarchical multiple regression analysis were conducted to examine the relationships among the variables. The results showed that perseverance of effort positively predicted all three achievement goal orientations and mathematics achievement. Consistency of interests positively predicted performance approach and performance avoidance goals, but it did not significantly predict mastery goals or mathematics achievement. Mastery goals had a significant positive relationship with mathematics achievement, whereas performance approach and performance avoidance goals did not show significant direct relationships with mathematics achievement. The decrease in the regression coefficient of perseverance of effort after mastery goals were added suggested a possible indirect role of mastery goals. These findings indicate that continued effort and mastery focused motivation are important for mathematics learning. Private high schools should support students in maintaining effort, setting clear learning goals, and responding positively to academic difficulties.

Keywords
Achievement goal orientations; Grit; Mathematics achievement; Perseverance of effort; Private high school students

1. Introduction

Grit is one personal quality that has received wide attention. Duckworth et al. (2007) defined grit as perseverance and passion for long term goals. This definition suggests that successful learning depends not only on having a goal, but also on continuing to work toward that goal over time. A student may begin a task with strong interest, but progress often requires repeated practice, correction of mistakes, and delayed rewards. Grit is therefore relevant to school subjects that involve a long period of knowledge building. Mathematics is a clear example

because new topics often depend on earlier knowledge, and students must continue practicing even when they do not understand a problem immediately. Previous research has also shown that motivation and commitment to learning are important factors associated with academic achievement among university students (Wu et al., 2025).

Most grit research describes two related dimensions. The first dimension is perseverance of effort. It refers to continued work, concentration, and practice in the face of difficulty. Students with stronger perseverance of effort are more likely to complete exercises, review errors, and try another method when an answer is incorrect. The second dimension is consistency of interests. It refers to maintaining attention to the same general goals rather than frequently changing direction. A student with consistent interests may remain interested in mathematics learning across a semester, while a student with lower consistency may move quickly from one interest to another. Although both dimensions belong to grit, they may not have the same relationship with academic outcomes.

Research on grit also has measurement limits. Some studies use students' self reported grades, which may contain memory errors or personal bias. Wolters and Hussain (2015) pointed out that self regulated learning and academic achievement should be measured with care when they are examined together with grit. A student who sees himself or herself as hardworking may also report higher grades, even when the official record is different. The present study reduced this problem by using a formal mathematics test provided by the school. This method does not remove every source of error, but it gives a more direct measure of students' performance in the subject.

Achievement goal orientation provides a useful framework for studying this motivational process. Achievement goals describe what students are trying to achieve and how they define success in a learning situation. Elliot and McGregor (2001) proposed a framework that separates goals according to competence and approach or avoidance tendencies. The present study focused on three goal orientations that are commonly used in educational research: mastery goals, performance approach goals, and performance avoidance goals. Each orientation can guide attention, emotion, and behavior in a different way.

Mastery goals focus on learning, understanding, and improvement. Students with strong mastery goals try to develop competence rather than only obtain a high score. They are more likely to view mistakes as information, ask questions, and use feedback to improve. In mathematics, mastery goals may support careful reasoning and repeated practice because the student's main purpose is to understand the process. Putwain et al. (2018) found that achievement goals were related to behavioral engagement and mathematics achievement. Their work supports the idea that learning goals may connect students' personal tendencies with their actual classroom performance.

Performance approach goals focus on showing higher ability than other students or obtaining a better result. This goal can encourage effort when students see competition as a positive challenge. However, it may also lead them to focus on scores, ranking, or public recognition rather than understanding. Performance avoidance goals focus on avoiding failure or avoiding the appearance of low ability. Students with this orientation may study because they do not want to make mistakes, receive criticism, or fall behind classmates. Such goals can produce effort, but they may also increase worry and reduce flexible problem solving.

Grit may be related to achievement goals because students who continue working toward long term aims are more likely to form clear learning purposes. Perseverance of effort may support

mastery goals because continued practice allows students to experience improvement. It may also support performance goals because students who care about achievement can work hard to gain a high position or avoid a low one. Consistency of interests may be related to goals that keep attention on evaluation over time, although its relationship with mastery goals is less certain. Reisz et al. (2013) argued that personality traits can act as predictors of personal goals, which provides a theoretical basis for examining grit as an earlier factor.

The relationship between achievement goals and mathematics achievement also requires further study. Mastery goals are generally expected to have a positive relationship with achievement because they encourage understanding, persistence, and the use of effective strategies. The results for performance approach goals are less consistent. Competition may increase effort for some students, but it may also narrow their attention to marks. Performance avoidance goals are often linked with anxiety and low confidence, yet students may still work hard to avoid failure. These mixed possibilities are especially relevant in high school mathematics, where external examinations and peer comparison are common.

The present study addressed this gap by examining students from private School A in Quanzhou, Fujian Province. Grade 10 is an important period because students are adjusting to high school courses and developing learning habits that may continue in later grades. Mathematics becomes more abstract at this stage, and students need to connect new concepts with earlier knowledge. A better understanding of grit and achievement goals may help teachers identify why some students continue working while others withdraw when they meet difficulty.

2. Objectives of the Study

The main purpose of this study was to examine the associations among grit, achievement goal orientations, and mathematics achievement among Grade 10 students in a private high school. Four specific questions guided the analysis. First, the study asked whether perseverance of effort and consistency of interests were related to mastery goals, performance approach goals, and performance avoidance goals. Second, it asked whether the two grit dimensions were related to mathematics achievement. Third, it examined whether the three achievement goal orientations predicted mathematics achievement after grit was considered. Fourth, it examined whether the change in the perseverance coefficient after mastery goals were entered was consistent with a possible indirect relationship.

3. Research Methodology

3.1 Participants and School Context

The study selected 256 Grade 10 students from private School A in Quanzhou, Fujian Province, China. Based on the school information used for this study, School A was listed among the top ten schools in Quanzhou in overall strength. This position indicated a relatively high level of educational quality and academic performance within the city. The participants were in the first year of high school and were taking the same general mathematics curriculum. Eight questionnaires were removed because they contained large sections of missing answers or showed the same response for nearly every item. The final dataset therefore contained 248 valid cases, which represented a valid response rate of 96.9 percent.

3.2 Research Instruments

3.2.1 Grit scale

The study used the eight item Short Grit Scale as presented in the work of Nishikawa et al. (2022). Four items measured perseverance of effort and four items measured consistency of interests. A perseverance item was, "I am a hard worker." A consistency item was, "Even when I am interested in something, I may become bored with it after a short time." The consistency items were reverse scored so that a higher value showed more stable interests. Students responded on a five point scale from 1, strongly disagree, to 5, strongly agree. The mean of the four relevant items was used for each dimension. In this study, Cronbach's α was .79.

3.2.2 Mathematics achievement goal orientation scale

Achievement goal orientations were measured with the nine item scale reported by Wu and Fu (2024). The scale contained three items for mastery goals, three items for performance approach goals, and three items for performance avoidance goals. A sample mastery item was, "I want to deepen my understanding of mathematics." A sample performance approach item was, "I want to perform better than other students in mathematics." A sample performance avoidance item was, "I study mathematics because I do not want to fall behind." Responses ranged from 1, strongly disagree, to 5, strongly agree. The mean of the three items was used for each orientation. In this study, Cronbach's α was .81.

3.2.3 Mathematics achievement

Mathematics achievement was measured with a formal school test administered one week after the questionnaire. The test covered the Grade 10 content taught during the relevant period and was scored from 0 to 100. The school mathematics teachers provided the scores for the students who completed the questionnaire. Using a formal test reduced the bias that may occur when students report their own grades. It also ensured that all students were assessed with the same content, time limit, and scoring rules.

3.3 Research procedure

The questionnaire was administered in April 2026 during a regular mathematics class at School A. Permission was obtained from the school and the mathematics teacher before data collection. At the beginning of the session, the researcher explained the purpose of the study in simple language. Students were told that there were no correct or incorrect answers to the questionnaire items and that honest responses were important. They were also told that the study would report group results rather than individual results.

3.4 Data preparation and analysis

Multiple regression analysis was then used to predict each achievement goal orientation from perseverance of effort and consistency of interests. Hierarchical multiple regression analysis was used for mathematics achievement. In Step 1, perseverance of effort and consistency of interests were entered. In Step 2, mastery goals, performance approach goals, and performance avoidance goals were added. Standardized regression coefficients, 95 percent confidence intervals, p values, R squared values, and changes in R squared were reported. A significance level of .05 was used. The variance inflation factors were below 2.00, which suggested that multicollinearity was not a serious concern in the regression models.

4. Findings

4.1 Descriptive Statistics and Correlations

After screening, 248 valid cases were included in the analysis. Table 1 presents the means, standard deviations, and correlations. Perseverance of effort had a mean of 3.42 and consistency of interests had a mean of 3.18. Among the goal orientations, mastery goals had the highest mean at 3.55, followed by performance approach goals at 3.31 and performance avoidance goals at 3.05. The average mathematics score was 74.22. These values suggested that the students generally reported moderate to moderately high effort and goal orientation.

Table 1. Descriptive statistics and correlations among the study variables

Variable	M	SD	1	2	3	4	5	6
1. Perseverance of effort	3.42	0.66	1					
2. Consistency of interests	3.18	0.71	.10	1				
3. Mastery goals	3.55	0.67	.48***	.06	1			
4. Performance approach goals	3.31	0.74	.29***	.23***	.38***	1		
5. Performance avoidance goals	3.05	0.79	.24***	.20**	.27***	.61***	1	
6. Math	74.22	11.74	.36***	.05	.38***	.14*	.08	1
*Note. *p < .05, **p < .01, ***p < .001.*								

The correlation between perseverance of effort and consistency of interests was small, r = .10. This result supported the decision to keep the two dimensions separate. Perseverance of effort was positively correlated with mastery goals, r = .48, performance approach goals, r = .29, performance avoidance goals, r = .24, and mathematics achievement, r = .36. Consistency of interests had small positive correlations with performance approach goals, r = .23, and performance avoidance goals, r = .20. Its correlations with mastery goals, r = .06, and mathematics achievement, r = .05, were weak.

Mastery goals were positively correlated with mathematics achievement, r = .38. The correlations of performance approach goals and performance avoidance goals with mathematics achievement were .14 and .08. Performance approach and performance avoidance goals had a relatively strong positive correlation, r = .61. This pattern showed that students who wanted to perform better than others often also wanted to avoid poor performance. However, the two goals had limited direct relationships with the formal mathematics score.

Table 2. Multiple regression analyses predicting achievement goal orientations

Predictor	Mastery goals		Performance approach goals		Performance avoidance goals	
	β [95% CI]	*p*	*β* [95% CI]	*p*	*β* [95% CI]	*p*
Perseverance of effort	.478 [.367, .589]	< .001	.270 [.152, .389]	< .001	.220 [.099, .341]	< .001
Consistency of interests	.016 [-.095, .127]	.773	.205 [.086, .323]	.001	.178 [.057, .298]	.004
R^2	.230		.126		.088	
Adj R^2	.224		.119		.080	
F	36.60		17.61		11.75	

4.2 Regression Analyses Predicting Achievement Goal Orientations

Table 2 shows the regression models for the three achievement goal orientations. The model for mastery goals was statistically significant, $F(2, 245) = 36.60$, $p < .001$, and explained 23.0

percent of the variance. Perseverance of effort was a positive predictor of mastery goals, beta = .478, 95 percent confidence interval [.367, .589], $p < .001$. Consistency of interests was not a significant predictor, beta = .016, 95 percent confidence interval [-.095, .127], $p = .773$. This result indicated that continued effort, rather than stable interest alone, was closely related to students' desire to understand and improve in mathematics.

The model for performance approach goals was also significant, $F(2, 245) = 17.61$, $p < .001$, and explained 12.6 percent of the variance. Perseverance of effort positively predicted performance approach goals, beta = .270, 95 percent confidence interval [.152, .389], $p < .001$. Consistency of interests was also a positive predictor, beta = .205, 95 percent confidence interval [.086, .323], $p = .001$. Students who continued working and maintained stable interests were therefore more likely to report a wish to obtain better results than other students.

The model for performance avoidance goals was significant, $F(2, 245) = 11.75$, $p < .001$, and explained 8.8 percent of the variance. Perseverance of effort positively predicted performance avoidance goals, beta = .220, 95 percent confidence interval [.099, .341], $p < .001$. Consistency of interests also had a positive effect, beta = .178, 95 percent confidence interval [.057, .298], $p = .004$. The size of these coefficients was smaller than the coefficient for perseverance in the mastery model. Overall, perseverance of effort was related to all three goal orientations, while consistency of interests was related only to the two performance goals.

4.3 Hierarchical Regression Predicting Mathematics Achievement

Table 3 presents the hierarchical regression results for mathematics achievement. In Step 1, the two grit dimensions explained 13.1 percent of the variance, $F(2, 245) = 18.41$, $p < .001$. Perseverance of effort was a significant positive predictor, beta = .360, 95 percent confidence interval [.242, .478], $p < .001$. Consistency of interests was not significant, beta = .015, 95 percent confidence interval [-.103, .133], $p = .802$. This result showed that students who continued working through difficulty tended to obtain higher mathematics scores, whereas stable interest alone was not directly related to the test result.

Table 3. Hierarchical multiple regression predicting mathematics achievement

Predictor	Step 1		Step 2	
	beta [95% CI]	***p***	**beta [95% CI]**	***p***
Perseverance of effort	.360 [.242, .478]	< .001	.239 [.107, .370]	< .001
Consistency of interests	.015 [-.103, .133]	.802	.022 [-.096, .140]	.715
Mastery goals			.283 [.147, .419]	< .001
Performance approach goals			-.012 [-.165, .140]	.872
Performance avoidance goals			-.050 [-.195, .095]	.497
R^2	.131		.189	
Adj R^2	.124		.173	
ΔR^2			.059	
F value	18.41		11.31	
ΔF			5.85	.001
Note. Step 1 included the two grit dimensions. Step 2 added the three achievement goal orientations.				

In Step 2, the three achievement goal orientations were added. The full model explained 18.9 percent of the variance in mathematics achievement, $F(5, 242) = 11.31$, $p < .001$. The increase in explained variance was 5.9 percent, and the change was statistically significant, change $F(3, 242) = 5.85$, $p = .001$. Perseverance of effort remained a significant predictor, beta = .239, 95 percent confidence interval [.107, .370], $p < .001$. Mastery goals were also significant, beta =

.283, 95 percent confidence interval [.147, .419], $p < .001$.

Consistency of interests did not significantly predict mathematics achievement in the full model, beta = .022, $p = .715$. Performance approach goals were also not significant, beta = -.012, $p = .872$, and performance avoidance goals were not significant, beta = -.050, $p = .497$. These findings showed that the two main predictors were perseverance of effort and mastery goals. The performance related goals were connected with grit, but they did not explain additional differences in the formal mathematics score after the other variables were considered.

The standardized coefficient for perseverance of effort decreased from .360 in Step 1 to .239 in Step 2. At the same time, perseverance strongly predicted mastery goals, and mastery goals predicted mathematics achievement. This pattern was consistent with a possible indirect pathway in which continued effort supports mastery focused motivation, which is then related to higher mathematics achievement. However, the study did not conduct a formal mediation test, and the cross sectional design did not establish the order of cause. The result should therefore be described as evidence of an association pattern rather than proof of mediation.

5. Discussion

5.1 Grit and Achievement Goal Orientations

The strongest relationship was between perseverance of effort and mastery goals. This finding is reasonable because mastery goals require students to focus on gradual improvement. Understanding mathematics often takes time, and progress may not be visible after one lesson. Students need to continue practicing, ask for explanation, and return to earlier mistakes. Perseverance of effort provides the behavioral basis for these actions. As students see improvement, they may also develop a stronger wish to learn for understanding. The relationship can therefore work in both directions, although the present design tested only an association.

Consistency of interests showed a different pattern. It predicted the two performance goals but did not predict mastery goals. One possible explanation is that stable interest in a general direction does not always mean a strong wish to understand a specific mathematics topic. Students may remain focused on academic success because of examination plans, family expectations, or future study goals. Such stability can support concern about relative performance without producing a deeper learning purpose. This explanation is tentative and should be tested in future studies with more detailed measures of subject interest.

5.2 Grit, Mastery Goals, and Mathematics Achievement

The second main finding was that perseverance of effort positively predicted mathematics achievement. This result agrees with the basic idea of grit. Mathematics learning requires repeated practice and the accumulation of knowledge. When students continue working after errors, they have more opportunities to identify weak points and correct them. They are also more likely to complete assignments and prepare for tests. These behaviors can gradually improve performance. The result also supports earlier studies that found perseverance to be more closely related to achievement than consistency of interests.

Mastery goals were the only achievement goal orientation that significantly predicted mathematics achievement in the full model. Students who aimed to understand and improve tended to obtain higher test scores. Mastery goals may support deeper processing because students pay attention to why a method works rather than only whether the final answer is correct.

They may also use feedback more effectively and show less withdrawal after mistakes. In mathematics, these behaviors are useful because one misunderstanding can affect later topics.

Performance approach and performance avoidance goals did not have significant direct effects after grit and mastery goals were controlled. A performance approach goal may increase study time, but the quality of learning can vary. Some students may use effective strategies, while others may focus on memorizing procedures for a short term score. Performance avoidance goals may also produce effort, but worry can reduce concentration. These opposite processes may cancel each other in a regression model, leading to a small average effect.

The reduction in the perseverance coefficient after mastery goals were entered suggests a possible motivational pathway. Continued effort may help students experience progress, and progress may strengthen the goal of improving competence. A stronger mastery goal may then guide students toward useful strategies and steady practice. At the same time, perseverance remained significant, so effort had an association with achievement beyond the measured goals. This pattern is consistent with a partial indirect relationship, but formal longitudinal or experimental research is needed before a causal explanation can be accepted.

5.3 Educational Implications

The findings have practical meaning for mathematics teaching in private high schools. Teachers should give attention not only to correct answers but also to the learning process that produces improvement. Feedback can recognize students for returning to a difficult problem, correcting an error, and trying a new method. This type of feedback connects effort with learning rather than with simple obedience. It may help students see that perseverance is useful when it is combined with reflection and strategy change.

Teachers can also support mastery goals by making learning objectives clear. At the beginning of a lesson, the teacher can explain what students should understand and how the new idea connects with earlier knowledge. At the end of the lesson, students can identify what they have learned and what remains difficult. Small improvement goals may be more helpful than a general instruction to obtain a high score. For example, a student can aim to explain the reason for each step in an equation or reduce a common type of calculation error.

Classroom tasks should provide a suitable level of challenge. Tasks that are too easy do not require perseverance, while tasks that are far beyond students' current ability may lead to withdrawal. Teachers can use a sequence from basic questions to more complex applications. When students meet difficulty, hints can guide them without giving the full answer. This approach allows students to experience effort, support, and success. These experiences may strengthen both perseverance and mastery focused motivation.

5.4 Limitations and Future Research

Several limitations should be considered. First, grit and achievement goal orientations were measured through self report questionnaires. Although the scales showed acceptable reliability, students may have responded in ways that reflected social expectations or their personal view of their learning behavior. Future studies should combine questionnaires with teacher ratings, classroom observations, learning records, or repeated measurements to obtain a broader account of effort and motivation. Using several sources would also reduce common method bias and allow researchers to compare reported persistence with observed study behavior. Such evidence may show whether students apply perseverance consistently across homework,

classroom tasks, examinations, and periods of academic difficulty.

Second, the study included students from one private school in Quanzhou. The school was described as academically strong, so the students may not represent private high school students in other areas. School climate, family background, admission practices, and teaching methods can differ across institutions. Future studies should include several private and public schools from different cities. A larger and more varied sample would improve the ability to apply the findings to other settings.

Third, the design was cross sectional. Grit, achievement goal orientations, and mathematics achievement were measured within a short period. The regression order was based on theory, but the data could not show the direction of influence. Higher achievement may also strengthen perseverance or mastery goals. Longitudinal research should measure the variables at several points during a school year. Such a design could examine whether earlier perseverance predicts later goals and whether later goals predict changes in achievement.

Finally, the hierarchical regression pattern suggested a possible indirect pathway through mastery goals, but a formal mediation analysis was not conducted. Future research can use bootstrap mediation, structural equation modeling, or longitudinal cross lagged models. These methods can provide a more direct test of the proposed process. Experimental studies can also examine whether teaching that supports mastery goals changes students' effort and mathematics performance over time.

6. Conclusion

This study examined the associations among grit, achievement goal orientations, and mathematics achievement among Grade 10 students in a private high school. The results showed that perseverance of effort was positively related to mastery goals, performance approach goals, performance avoidance goals, and mathematics achievement. Consistency of interests was related to the two performance goals but not to mastery goals or mathematics achievement. Mastery goals positively predicted mathematics achievement, while the two performance goals did not have significant direct effects. The pattern also suggested that perseverance of effort may support achievement partly through mastery focused motivation.

The findings highlight the value of continued effort in mathematics learning. Students need support to remain engaged when they meet difficult concepts, repeated errors, and slow progress. At the same time, effort should be connected with clear mastery goals and effective learning strategies. Private high schools can support this process through suitable challenge, process focused feedback, opportunities to revise work, cooperative problem solving, and regular reflection on learning goals. Further research across different schools and time periods can test the stability of these associations and clarify how motivation develops during high school mathematics learning.

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Conflicts of Interest

The author(s) declare no conflicts of interest regarding the publication of this paper.

Ethics Statement

The study was conducted in accordance with appropriate ethical standards. Participation was voluntary, and informed consent was obtained from all participants. Participant anonymity and confidentiality were maintained throughout the study.

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