Computer Programming Practice, Grit, and Learning Outcomes in Computing Education

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Abstract. This research examines the gaps in programming education literature by analysing the discrepancies between the frequency of programming practice, levels of grit, and the vocational learning outcomes of computing students. Adopting a quantitative correlational approach, the research assessed 87 students from three Indonesian vocational high schools. The collection of data employed the use of standardised questionnaires to determine the programming practice frequency (PPF) and grit level (GL) (measured via the Short Grit Scale). At the same time, learning outcomes (LO) were evaluated at a grade level in Programming Fundamental Subject (PFS). From a statistical standpoint, a correlation of 0.301 was observed between PPF and LO, which, although low, was still surprising when considered in light of benchmarks provided by practice theory. Most tellingly, GL showed no correlation with LO, countering those psychological frameworks which view grit as a fundamental predictor of success in education. Furthermore, the PPF showed a slight, positive correlation of 0.312 with GL. In combination, these factors demonstrated a slight cumulative influence of 0.303 regarding the LO. These findings suggest that the relationships among programming practice frequency, grit, and learning outcomes are weak and context-dependent. The findings indicate that current teaching frameworks may need to be reconsidered in vocational computing education. In addition, the low correlations suggest that the acquisition of procedural skills in computing is likely to depend more on psychological factors, the quality of teaching, or educational technologies than on sheer frequency of practice alone.

Keywords: programming education, vocational education, learning outcomes, grit, computing education.

1 Introduction

As a consequence of the digitalisation of economics and social life, the demand for skilled computer programmers has accelerated while simultaneously marking a decline in programming competency levels within vocational education institutions globally [29, 37]. These

© The Author(s) 2026
M. Murtadha et al. (eds.), *Proceedings of the 2026 11th International Conference on Sustainable Information Engineering and Technology (SIET 2026)*, Atlantis Highlights in Computer Sciences 26,
https://doi.org/10.2991/978-94-6239-828-3_29

computing programmes emphasised quick graduate employment, creating a gap between industry needs and what schools were teaching [3]. The cumulative impact of these systemic concerns is intensified by the traditional belief that intensive practice directly correlates with improved learning results [1, 2]. It has dominated the teaching of programming for decades without empirical validation.

Up until now, it has been understood that in a thorough programming educational history, deliberate practice pace equates to procedural knowledge acquisition as one invests effort and develops mastery skills [12–14]. This school of thought has been contradicted by ample evidence that the frequency of practice may not be the best predictor of learning in computing education [16]. Alongside this, educational psychology once again comprehends self-phenomena beyond the boundaries of the curriculum, leaning more towards social aspects such as grit, construing these as powerful predictors of performance across a multitude of subjects [11, 27]. To date, however, the computing education literature has yet to be empirically investigated to determine whether grit is a reliable predictor of success, creating a significant scholarly and practical gap. This gap becomes more pronounced when analysing the distinct characteristics of vocational education, wherein students engage with a specialised type of procedural knowledge driven by various motivational and cognitive scaffolding systems [17], differentiated from those found in more generalised scholarly paradigms. Accordingly, this study addresses three research questions: (1) Does programming practice frequency relate to learning outcomes in vocational computing education? (2) Does grit relate to learning outcomes in vocational computing education? (3) How do programming practice frequency and grit together relate to learning outcomes in vocational computing education?

2 Theoretical Framework

Programming education has frequently drawn on Ericsson's deliberate practice framework, which argues that achieving proficiency hinges on persistent and focused effort [8]. Cognitive load theory has been incorporated into this framework to describe what occurs during repetitive coding exercises and why they must be managed to prevent exceeding the students' working memory capacity, especially in the early phases of developing procedural knowledge [22, 28, 32]. According to Duckworth, grit consists of consistency of interest and perseverance of effort over time [7]. However, within the body of literature, questions have arisen concerning the specificity of academic disciplines, which underline whether the predictive power of grit is the same across different subject areas or learning environments [33]. These ideas become particularly important when looking at the distinctive features of vocational education contexts.

The situated learning theory offers an insightful approach to understanding knowledge acquisition in vocational education, stressing that effective learning occurs through active participation in authentic communities of practice [20]. The divide between theoretical

education and practical training has been identified as a primary concern in computing vocational programmes. These reflections emphasise the need to explore the processes through which theoretical knowledge transforms into professional competencies [21, 40]. The development of procedural knowledge in the context of programming has been studied extensively concerning Anderson's ACT-R (Adaptive Control of Thought-Rational) theory, which outlines the cognitive "hardware" involved in the processes of skill compilation [31]. This theory describes the automation process in programming where understanding concepts and the relevant codes are practised until fluent coding behaviour is achieved. It requires a considerable amount of practice for students to develop the necessary cognitive automation to accomplish complex tasks that involve automatic decision-making [6].

This investigation aims to address the fundamental research questions that focus on the interplay between programming practice frequency, grit, and learning outcomes in vocational computing education contexts. This caveat regarding vocational settings is important because the second research question seeks to determine the extent to which grit can be considered a reliable predictor of academic success within Programming Fundamental Subject (PFS) modules, thereby testing the relevance of non-cognitive variables in professionally oriented education, where instruction revolves around the acquisition of skills and knowledge.

3 Methods

This study examined the relationships among programming practice frequency (PPF), grit level (GL), and learning outcomes (LO) in vocational computing education. The study used a quantitative cross-sectional correlational design. The population included 268 software engineering students from three vocational high schools in Malang, Indonesia. Participants were determined through cluster sampling, and the sample size was calculated using Slovin's formula, resulting in a final sample of n = 87 who mastered software engineering in narrow, specialised vocational curricula.

Programming practice frequency was measured using a seven-item open-ended questionnaire that recorded weekly hours of coding practice outside class sessions. Content validity was confirmed using Aiken's Validity tests in expert judgement processes, which established a minimum of 0.75 for all relevant domains about the measurement. Grit was measured using the Short Grit Scale (Grit-S), an eight-item Likert scale assessing consistency of interest and perseverance of effort. Learning outcomes were obtained from PFS academic performance records and checked across the three schools for comparability. Data were analysed using descriptive statistics, normality testing, Pearson correlation, Spearman correlation, Kendall's tau, power analysis, and bootstrap confidence intervals. Because the design was correlational, the study does not support causal interpretation or control for prior ability, teacher quality, or socioeconomic background. Relevant ethics review committees granted full ethical clearance confirming that the informed consent processes protected

respondents' rights and guaranteed their voluntary participation in this study, especially within the context of acquiring procedural knowledge during education about specific vocations.

4 Results

Programming practice was highly skewed, with 56.3% of students in the least frequent category. This indicates that most students reported limited independent coding outside class. Grit scores were approximately normally distributed, with a mean of 3.16 and standard deviation of 0.48. Learning outcomes were negatively skewed, with 58.6% of learners in the highest performance band. This indicates that learning outcomes were concentrated at the higher end of the scale.

Table 1. Descriptive Statistic Summary

Statistical Measure	PPF	GL	LO
Sample Size (n)	87	87	87
Measures of Central Tendency			
Mean (M)	7.29 hours/week	3.16	81.83
Median (Mdn)	5.00 hours/week	3.13	84.00
Mode	5.00 hours/week	3.38	85.00
Measures of Variability			
Standard Deviation (SD)	6.05	0.48	9.25
Variance (σ^2)	36.36	0.23	85.63
Range	26.00 hours	2.38	58.00
Minimum Value	0.00 hours/week	1.88	40.00
Maximum Value	26.00 hours/week	4.25	98.00
Quartiles			
First Quartile (Q1)	2.92 hours/week	2.88	79.00
Third Quartile (Q3)	10.00 hours/week	3.50	87.00
Interquartile Range (IQR)	7.08 hours	0.62	8.00
Validity & Reliability			
Content Validity (Aiken's V)	0.75 - 1.00	0.83 - 1.00	N/A (Secondary data)
Reliability (Cronbach's α)	N/A (Open-ended)	0.73 - 0.83	N/A (Secondary data)
Test-Retest Reliability	N/A	r = 0.68	N/A
Demographic Breakdown			
Male Participants (n=55)	M = 7.45, SD = 6.23	M = 3.18, SD = 0.49	M = 82.1, SD = 9.4
Female Participants (n=32)	M = 6.98, SD = 5.72	M = 3.12, SD = 0.46	M = 81.3, SD = 8.9

PPF: programming practice frequency; GL: grit level; LO: learning outcomes.

The first set of correlational analyses showed a weak positive relationship between programming practice frequency and learning outcomes. Programming practice frequency had a weak positive correlation with learning outcomes ($r = 0.301$, $p = 0.005$), which was

classified as small to medium according to Cohen's conventions for effect size, indicating that there was a statistically significant but practically limited association between coding practice frequency and academic achievement in PFS. This finding indicates a statistically significant but practically limited association.

Table 2. Statistical Power Analysis

Relationship	Observed r	r^2	EF	SP	Required n for Power = 0.80
PPF ↔ LO	0.301	0.091	Medium	0.82	84
PPF ↔ GL	0.312	0.097	Medium	0.84	79
GL ↔ LO	0.128	0.016	Small	0.21	469
Multiple Correlation (Combined Predictors)	0.303	0.092	Medium	0.80	85

Effect size classifications: Small (r = 0.10), Medium (r = 0.30), Large (r = 0.50) according to Cohen (1988); Current sample n = 87; EF: effect size; SP: statistical power.

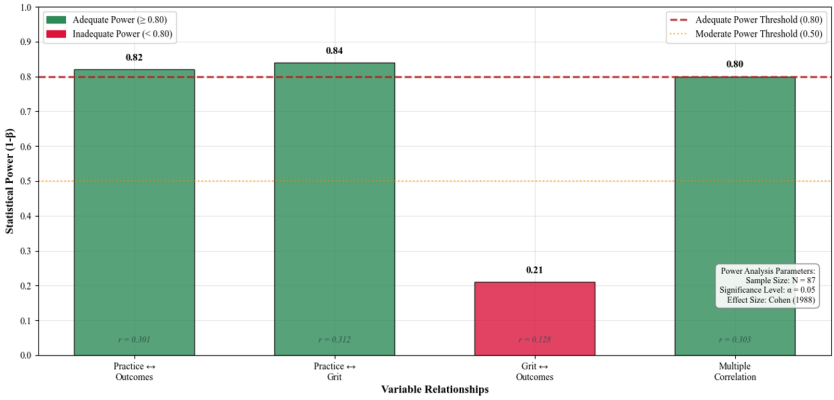


Fig. 1. Statistical Power Analysis

The correlations also show that programming practice frequency and grit are weakly related. The level of practice in programming exhibited a weak yet significant positive correlation with grit (r = 0.312, p = 0.003), suggesting a degree of interdependence between these variables. It implies that learners who utilise coding more frequently have displayed somewhat greater levels of grit. The correlation that emerged not only challenged existing theoretical assumptions within the practice behaviour motivation-centric model but also proposed that the divergent frequency of programming activities defies the intrinsic motivational characteristics often associated with grit in educational psychology. The results from multiple correlation analyses characterising the combined effect of programming practice frequency alongside grit levels on learners' outcomes yielded R = 0.303 (p = 0.017),

highlighting a statistically significant, albeit practically negligible, collective power for explaining achievement in PFS. Other variables may also influence learning outcomes, but they were not measured in this study.

To corroborate the reliability and accuracy of the correlational results, the processes of data transformation and sensitivity analysis were applied, thereby reinforcing confidence in the findings derived from this study. The programming practice frequency and learning outcomes variables exhibited distributional irregularities, which were addressed through a two-step approach to normalisation procedures, enabling the use of parametric statistical techniques while maintaining their relationships. Diverse analytical approaches, integrating different statistical methods, enabled cross-method corroboration of correlation patterns and confirmed the rigour of relations and factors shaping learning outcomes in vocational computing education concerning the frequency of practice and grit, thereby confirming anomalous results. Bootstrap confidence interval procedures were employed to validate effect size estimates, providing additional evidence for the practical significance of weak correlations observed between traditional predictors and academic achievement in PFS.

Table 3. Comparative Analysis of Correlation Methodologies

Relationship	Pearson r		Spearman ρ		Kendall's τ		Comparison	
	C	p	C	p	C	p	F	p
PPF ↔ LO	0.301	0.005	0.284	0.008	0.197	0.009	2.847	0.063
GL ↔ LO	0.128	0.236	0.145	0.182	0.098	0.205	0.453	0.637
PPF ↔ GL	0.312	0.003	0.298	0.005	0.206	0.006	1.923	0.153
Average Absolute Difference	-	-	0.019	-	0.108	-	-	-

PPF: Highly skewed (Skewness = 2.41, Kurtosis = 6.78); GL: Approximately normal (Skewness = 0.12, Kurtosis = -0.43); LO: Negatively skewed (Skewness = -1.89, Kurtosis = 4.23); C: Coefficient; F: F-statistic.

5 Discussion

The findings suggest that repetitive programming practice alone may not be sufficient to improve learning outcomes [4]. Skill acquisition within vocational education has received critique due to the reductive pedagogical model of rote memorisation, specifically the cloning of coding exercises, raising the age-old controversy of the value of procedure knowledge accumulation [34, 35]. The paradigms of the IT industry concerning education designed for particular roles have been scrutinised thoroughly, debunking the myth of the '10,000 hours' paradigms of programming skills acquisition, showcasing that mere time expenditure does not cut it in the domain of professional education [26, 38]. The results are consistent with the view that grit may function differently across educational contexts [25, 30, 33]. These findings suggest that motivational models developed in other settings may not fully apply to vocational computing education [10].

This study suggests that reconsidering cognitive ability, teaching effectiveness, and technology-supported educational settings as more relevant predictor variables than frequency metrics in conventional programming practice is essential for success [5, 9, 18, 19, 23]. Social context factors in vocational education have emerged as an essential focus by suggesting that peer mentorship and authentic work-integrated learning may be more potent than students' attributes in shaping achievement outcomes [15]. This study does not provide strong support for practice-centric models in this sample [24, 36, 39]. Because the study did not measure prior ability, instructional quality, access to computers, or socioeconomic background, these variables should be examined in future research.

6 Conclusions

This study found weak associations between programming practice frequency, grit, and learning outcomes in vocational computing education. The results do not support grit as a strong predictor of learning outcomes in this context. The findings suggest that vocational programming education should be interpreted with caution and studied alongside additional learner and school factors. The all-encompassing change in computing education research and practice that this study has provoked is unprecedented and will require new, enduring partnerships between universities, employers, and government if vocational programming education is to prepare learners for successful employment in the modern IT industry.

Acknowledgments. The authors would like to thank the students and faculty members for their participation and organisational support. The authors also thank the school administrators and teachers who supported data collection.

Disclosure of Interests. The authors declare no competing financial incentives or personal affiliations that could have influenced the study

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