mentary students' computational thinking and gaming behavior (i.e., total number of cards played, number of bugs, number of tactic cards played, and number of programming cards played) in the educational programming board game. Data collected in the game were examined through an analysis of covariance (ANCOVA) to yield statistics on learning outcomes. An independent-sample U test was used to assess their gaming behavior. The results of the aforementioned analyses are discussed as follows.

4.1 Descriptive statistics for the research variables

Table 1 summarizes the descriptive statistics of field-independent and field-dependent participants' learning outcomes and gaming behavior in the programming board game. In both pretests and posttests, the field-independence group (mean pretest score: 36.92 of 100; mean posttest score 69.62 of 100) outperformed the field-dependent group (mean pretest score: 28.33; mean posttest score 49.58), likely because field-independent learners tend to immerse themselves in learning, have greater intrinsic motivation, and learn more efficiently [16].

Table 1: Descriptive statistics for the research variables

Learning Outcomes	FD(N=12)		FI(N=13)		ALL(N=25)	
	M	SD	M	SD	M	SD
Computational Thinking						
Pretest	28.33	24.80	36.92	26.89	32.80	25.22
Posttest	49.58	28.64	69.62	12.49	60.01	23.15
Gaming Behavior						
Total number of cards	9.44	4.64	9.22	3.83	9.33	4.01
Num. of bugs	0.89	1.45	1.67	1.32	1.28	1.37
Num. of tactic cards	1.78	1.85	1.78	1.09	1.78	1.44
Num. of program cards	2.00	1.87	3.78	3.07	2.89	2.56

4.2 Field-independent students have better learning performance

An ANCOVA was performed on posttest scores, with pretest scores used as a covariate to control for the influence of participants' prior knowledge. An intragroup regression coefficient homogeneity test was performed on the pretest scores of both participant groups to ensure no significant difference was present. The result shows that the F value was 2.939, whereas the p value was .101 (> .05), indicating no significance and accepting the null hypothesis. Therefore, the covariate (the pretest score) and the dependent variable (the posttest score) corresponded to the hypotheses of the intragroup regression coefficient homogeneity test for ANCOVA, prompting ANCOVA to be further conducted.

Next, a one-way ANCOVA was conducted to assess differences in the posttest score between participant groups (Table 2). By controlling for the influence of the pretest score, significant differences were found in the posttest score between the groups ($F = 4.480, p = .046 < .05$). After post hoc comparison, the results suggested significant improvements in learning outcomes on computational thinking for field-independence group, with a mean deviation of 16.18.

Table 2: One-way ANCOVA of posttest of cognitive style students' computational thinking

Source	SS	df	MS	F	p	η^2
Covariance (pretest)	3106.36	1	3106.36	8.770	.007	.285
Between group effect	1586.22	2	1586.22	4.480	.046*	.169

In-group (error)	7789.63	22	354.07
Total	103400.00	25	

*$p < .05$

Based on the statistical results, the use of board games as a teaching material for programming courses can yield noticeable learning outcomes in learners with different cognitive styles. Previous studies have indicated that in complex gaming scenarios, field-independent learners have stronger learning motivation and are more capable of acquiring clues to solving problems, and more likely to participate in learning activities, generally have higher intrinsic motivation and show more efficient learning outcomes [24], this proposition is supported by the results of this study. However, because King of Pirates both introduces programming concepts and exhibits board game elements, further research should be conducted to ascertain whether the concepts or the gaming elements is attributable for the improved learning outcomes achieved by the field-independent participants in this study.

4.3 Field-independent students seem showing more computational thinking and more trial-and-error behavior

Table 3 shows the non-parametric statistics (Mann-Whitnet U test) results of students' gaming behavior between the participant groups.

Table 3: The Mann-Whitnet U test result of students' gaming behavior

Gaming Behavior	FD (N=12)		FI (N=13)		Significances	Summary
	M	SD	M	SD		
Total number of cards	9.44	4.64	9.22	3.83	.976	FD≈FI
Num. of bugs	0.89	1.45	1.67	1.32	.190	FD<FI
Num. of tactic cards	1.78	1.85	1.78	1.09	.666	FD≈FI
Num. of program cards	2.00	1.87	3.78	3.07	.222	FD<FI

The groups showed no significant difference in gaming behavior (Table 3); yet, there were noteworthy findings about their gaming behavior. First, there existed slight differences in the total number of cards played and number of tactic cards played between the groups. This was either because field-independent and field-dependent participants showed no marked differences in their game involvement (the total number of cards played) and gaming tactics (the number of tactic cards)

Second, the programming cards used in the game "IF… Else," "And/Or," and "Loop" served to enhance players' knowledge of programming, and players who used these three cards could gain an advantage. Moreover, players who used common cards (e.g., "Move Forward," "Move Backward," "Turn Right," and "Turn Left") were more likely to encounter a lower number of bugs (the number of bugs related to the number of points deducted for logic errors in the combination of cards that occurred when a player used cards to advance toward a target). Although U-test results indicated no significant difference in the number of programming cards played and the number of bugs between the participant groups, the field-independence group seems to occur more use of the program card and more bugs behavior (3.78 for the number of programming cards played and 1.67 for the number of bugs). This result is consistent with the phenomenon observed by the research team during the teaching process.

5 Conclusions

This study compared learning outcomes and gaming behavior in an educational programming board game between learners with different cognitive styles. Conclusions derived from the analysis of the findings are as follows. First, in the programming board game, field-independent learners achieved significantly improved learning outcomes over field-dependent learners. Second, although there is no significant difference was found in gaming behavior between field-independent and field-dependent learners, the field-independence group demonstrated more learning behavior related to the execution of complex thinking and more trial-and-error behavior. These conclusions indicate that to provide differentiated instruction for learners with different cognitive styles, should be more to enhance the programming learning performance and positive play behavior.

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