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Artificial Intelligence-Dominated World: Can Cognitive Style Moderate Contribution of Students' Creativity to Programming Achievement?

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Abstract

Programming skills are indispensable for the development of Artificial Intelligence (AI) tools. However, secondary school students often encounter difficulties in this particular aspect of computer science. This study investigated the moderating influence of students' cognitive styles on the contribution of their creativity to their learning of programming. Utilizing the correlational design, the study surveyed 270 senior secondary school three (SS3) students from public senior secondary schools in the Ikeja Local Government Area, Lagos State, Nigeria. The survey data was collected using the Students' Achievement Test in Programming (r=0.74), Programming Creative Style Inventory (0.86), and Cognitive Style Inventory in Programming (r=0.76). The data collected were analysed through descriptive statistics of mean and standard deviation and inferential statistics of hierarchical multiple regression.The findings of the study indicated that both creativity and cognitive styles significantly contributed to students' programming learning. However, cognitive style did not play a moderating role in the influence of creativity on students' programming achievement. From these findings, the study recommended that teachers promote students' creativity by employing essay questions rather than multiple-choice formats and adapt their instructional strategies to cater to the diverse needs of learners, regardless of their cultural backgrounds. This study sheds light on the significance of creativity and cognitive style in programming learning, and the findings can be utilized to design interventions aimed at enhancing programming learning among students with varying cognitive styles.

Keywords: cognitive styles, creativity, artificial intelligence, students' achievement, programming

INTRODUCTION

Every nation strives to achieve sustainable development goals by 2030. Mhlanga (2021) argued that Artificial Intelligence (AI) could strongly influence the attainment of these goals, especially poverty alleviation, improvement in transport infrastructure, and development of the economy in emerging markets. AI can determine countries' economic policies and is a prominent predictor of world economic growth during economic downturns (Smirnov & Lukyanov, 2019). Indeed, it is one of the recent advancements in technological development drives.

Artificial Intelligence depicts the ability of a machine to perform human-like tasks such as problem-solving, games, and medical examinations. It can potentially change the economy dramatically and perfectly do human jobs (Furman & Seamans, 2019). According to Saetra (2020), the capability of AI in decision-making is better than that of human beings in some aspects, especially in areas of complex reasoning and analysis of large amounts of data for problem-solving. Although many nations use AI to improve their lots, only a few develop AI tools. It is argued that the benefits from such applications go to the countries of origin that control the data. This observation means that every nation should chart a path that will enable their citizens to develop the skills to develop AI tools. Several skills are needed to create AI tools. These include technical skills such as a strong foundation in computer science, programming, and mathematics. Others are algorithm design, creativity, problem-solving, and communication skills. The skill requirement suggests that any nation that wishes to be part of AI development to localise its gains must encourage programming learning.

Programming involves writing instructions for the computer to perform certain operations seamlessly without human intervention, thus promoting human-computer information exchange. It is regarded as one of the literacy skills of the 21st century which every individual must possess because it transforms individuals from passive consumers to active producers of technologies such as AI tools. Programming can also improve creativity and collaboration among individuals regardless of their geographical location and language disparity. It is an aspect of Science, Technology, Engineering, and Mathematics (STEM) education to develop learners' computational thinking, motivation, and engagement and can boost their career interests in computer science (Sun et al., 2021). Critical thinking, problem-solving, communication, and collaboration promoted by programming are strongly needed in this era of Artificial Intelligence.

However, it has been observed that programmers are still scarce worldwide, and this has a disproportionate impact on the innovation ambitions of numerous industries (Garcia & Revano, 2021), including AI. Similarly, Unique (2021) observed that the demand for occupations requiring programming abilities would increase dramatically over the next decade with a severe shortage of human resources with this skill. This observation implies that AI tool consumers will outnumber the developers of this device, which may likely overburden these few experts. Through the Federal Ministry of Communication Technology (2012), the Nigerian government emphasises developing indigenous programmers to meet the ever-rising demand for a workforce with programming skills. One of the platforms through which the skill can be inculcated in learners is through functional education. Therefore, the Federal Ministry of Education (FME, 2017) maintained that the curriculum would be reviewed to address emerging and future market needs, including coding, Artificial Intelligence, and robotics.

Computer Studies/Education was introduced into its senior secondary education curriculum in 2011. The primary objective was to provide learners with the needed skills and knowledge to function effectively in a digital economy. The thematic curriculum emphasises creativity and includes a problem-solving skill development theme to teach learners how to write effective computer programs to solve real-life problems. It also promotes critical and analytical thinking and effective communication. The spiral nature of the curriculum ensures that learners have repeated exposure to programming learning throughout the senior secondary education stage. This repeated exposure helps to reinforce and build upon previously learned concepts, resulting in a more robust understanding of programming concepts and their applications. Practical programming skills are sine-qua-non for meaningful participation in the artificial intelligence-dominated world.

Students' performance in programming in senior secondary school computer education has been below expectations, as shown by WAEC Chief Examiners' reports from 2014-2019. The 2017 report showed improvement, but this may be because there was no programming question in the essay part. In 2018, students avoided programming questions, and few students who attempted them demonstrated poor mastery. The 2019 report showed that students performed well in the theme, but the question was on flowcharts, not coding. Similarly, Oyelami, Oyebisi, and Afolayan (2017) reported that most secondary school students in Nigeria do not understand programming concepts and lack the necessary skills to write basic programs.

Consistently, WAEC external examiners' reports (2014-2019) blame students' poor performance in programming on teachers' lack of skill and effective tutorship, schools' lack of computer facilities, and epileptic power supply (Adeyanju & Adewale, 2021). Research has shown that many students in Nigeria lack interest and motivation in learning programming and have limited exposure to it (Oyelami et al., 2017). Despite research on how to improve students' programming knowledge (Saka, 2020; Akinola, 2016; Odo & Odo, 2016), students' poor performance persists, calling for a new approach. Thus, examining if cognitive style moderates the impact of students' creativity, a critical 21st-century skill, on their programming learning is a potential approach.

Creativity is a fundamental cognitive trait of individuals that enables them to develop fresh and helpful ideas or solutions to problems. It is the capacity to connect seemingly unrelated concepts, approaches, and challenges from different angles. According to Taheri et al. (2021), creativity is a crucial component of human cognition that helps individuals adapt to new contexts and difficulties to discover unique solutions to complex problems. Indeed, creativity is essential for the societal future, and its development is vital for science education (Fredagsvik, 2021). It is one of the must-have skills in the 4^{th} Industrial Revolution, a beacon of hope to solve many global issues, and core to an individual's successful contribution to a 21^{st}-century society characterised by complex and interconnected challenges (Henriksen et al., 2016). It has also been noted that creativity rules the world as medieval skills are no longer adequate to navigate the highly technologically connected global village. Chan and Yuan in Richardson and Mishra (2018) describe creativity as a core skill of 21^{st}-century that every education system should strive to promote.

LITERATURE REVIEW

Creativity has been found to aid an individual's ability to improve learning outcomes in various disciplines. The systematic literature review by Lutfiani (2021) concluded that creativity influences students' achievement because creative instructional delivery encourages students' absorption of lesson materials. Sawaluddin et al. (2022) analysed the effect of creativity on students' outcomes at Madrasah Tsanawiyah NurulYaqin, Pekanbaru, and found that it significantly positively impacted their learning. Prakoso et al. (2021) determined the relationship between creativity, critical thinking, and students' academic achievement, and it was reported that critical thinking and creativity were potent factors in students' academic achievement. Motivated by the persistent poor performance in Economics in Sekolah Menengah Atas (SMA) Ekasakti Padang, Nofrialdi (2022) explored the effect of creativity and interest on students' learning achievement and found a significant influence of creativity on it. It was revealed that creativity accounted for 14% of students' variance in academic achievement, and the study concluded that the higher the students' creativity, the better the learning achievement. Likewise, Wulanningtyas and Fauzan (2022) determined the impact of creativity on how students learn at SMK Negeri 3 Kendal through observation, interviews, and documentation. They disclosed that creativity significantly influenced the academic achievement of the students. Conversely, Saka et al. (2021) explored how the think-pair-share programming strategy affects students' learning of programming in computer studies in senior secondary schools. The study, which also examined the moderating effect of creativity, found a significant impact of the strategy but an insignificant effect of creativity on students' programming learning.

Another vital learning factor is the cognitive style, which refers to how an individual prefers to process information and approach problem-solving tasks. Yeldham and Gao (2021) described the cognitive style as a person's way of mentally perceiving, organising, and generalising information. Armstrong, cited in Yeldam and Gao (2021), argued that while the environment can influence learning styles, cognitive style is relatively stable and unaffected by the learners' environment. To this end, learners' cognitive styles determine the suitability of applied instructional strategies (Chuang et al., 2021). It also impacts their psychometric abilities (Mertayasa et al., 2021). A student's cognitive style substantially affects their capacity to grasp, remember, and apply information. According to Janah et al. (2021), students' cognitive styles are deemed appropriate if solutions to one problem in a domain can be used to overcome future challenges. Thus, knowing the various cognitive styles of students enables educators to adjust their instructional approaches and materials to meet their needs better, resulting in more successful learning results.

There are a variety of cognitive styles: field-dependent and field-independent, visual-spatial, verbal-linguistic, auditory-musical, adaptation-innovation, logical-mathematical, bodily-kinesthetic, interpersonal, and intrapersonal. Each form represents a distinct information processing method and has strengths and drawbacks. This study adopted the adaptation-innovation cognitive style due to its relationship with programming, which revolves around problem-solving. Kirton (1976) created the dichotomous adaptation-innovation cognitive style to assess an individual's approach to problem-solving and creativity. A learner with an adaptive cognitive style prefers solving problems using established methods and procedures, while an innovative cognitive style learner tends to favour new and unusual ways (Kirton, 2003). Research has indicated that an individual's level of adaptation and innovation could impact their success in various contexts.

Ifelunni et al. (2022) conducted a study to explore how cognitive styles impact the academic achievement of students in the South East region of Nigeria. The researchers utilized the Group Embedded Figure Test (GEFT) and the academic achievement proforma to collect data. The results of the study indicated a significant influence of cognitive style on students' academic performance. Similarly, Eriba et al. (2021) researched the effects of cognitive style and collaborative instructional strategy on senior secondary school students' chemistry learning in Benue State, Nigeria. It revealed a significant effect of cognitive style on students' academic achievement and recommended that teachers incorporate instructional strategies catering to learners' diverse cognitive styles. Similarly, Hamzah and Baa (2022), which examined the influence of cognitive style on the English skills of vocational high school students in Makasar, found that the correlation between students' cognitive styles and their productive skills was a weak but positive. Specifically, cognitive styles accounted for 14.8% and 20.5% of the variances in students' writing and speaking abilities, respectively. It was concluded that the correlation between cognitive style and the productive English skills of eleventh-grade students in Telkom Makasar during the 2020/2021 academic year was significant.

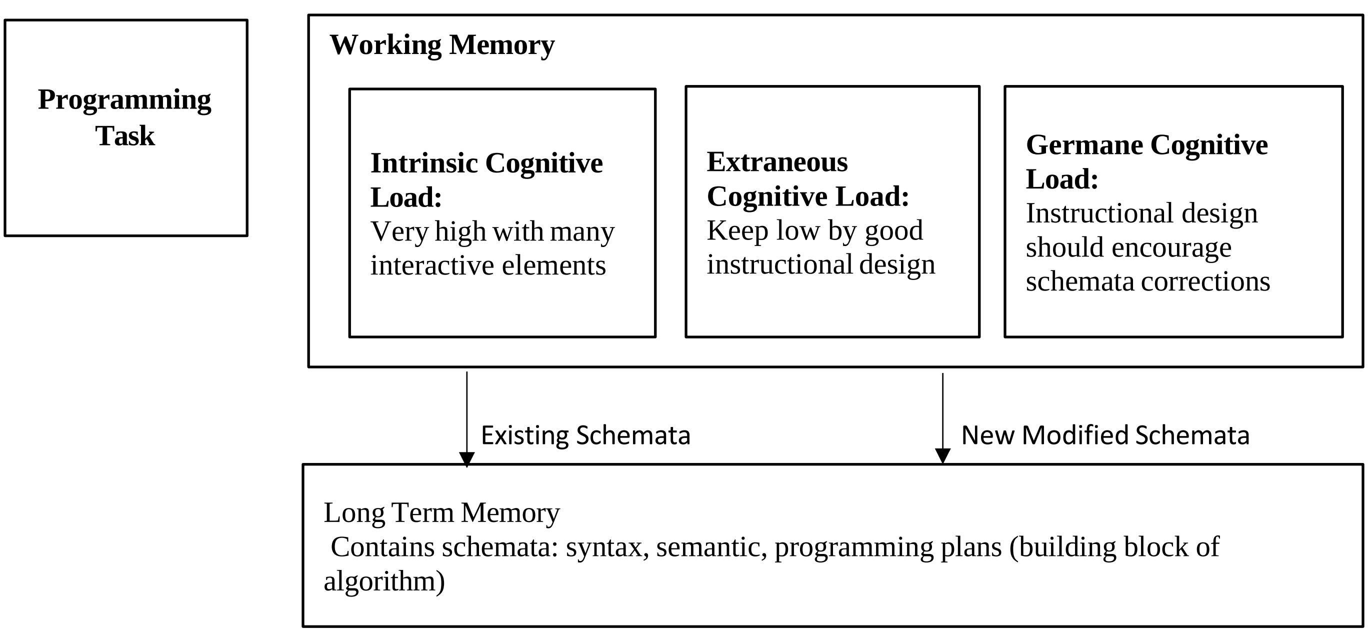
Beghetto and Kaufman (2014) have reported that both creativity and cognitive style can influence the performance of students in various aspects of learning. Research works have explored the moderating influence of cognitive style on the association between creativity and students' achievements. These investigations, however, have focused on areas other than the programming areas of computer studies in senior secondary schools in Nigeria. For example, Zhou et al. (2016) determined the moderating influence of cognitive style on the correlation between creativity and academic achievement among elementary school students in China. Their findings revealed that the intuitive cognitive style moderated the relationship between creativity and academic achievement, with creative-intuitive students performing better than their non-creative counterparts. Similarly, Oztunc (2013) examined how cognitive styles moderate cognitive style and personality factors to influence the connection between creative potential and creative performance. Furthermore, the study investigated the moderating influence of cognitive styles on the relationship between these variables. The results indicated that cognitive style moderated the connection between creative potential and creative performance.

THEORETICAL FRAMEWORK

Meanwhile, this work is guided by Cognitive Load Theory, proposed by John Sweller in 1988. Figure 1 explains the relevance of Cognitive Load Theory to this work.

Figure 1

Diagram Depicting Relevance of Cognitive Load Theory to Programming Learning *(Adopted from Garner, 2002).*



Cognitive Load Theory (CLT) provides a crucial framework for understanding the moderating role of cognitive style on the influence of creativity in programming learning. Programming tasks inherently demand a high intrinsic cognitive load due to their complexity, which involves mastering syntax, semantics, and problem-solving strategies such as algorithm development. Managing this load well is essential to avoid overwhelming learners and to support their ability to acquire new skills. In programming learning, it is crucial to minimize the extraneous cognitive load. This can be achieved through effective instructional design strategies, such as using clear explanations, intuitive learning environments, and avoiding distractions or irrelevant information. Simultaneously, educators must strive to enhance germane cognitive load by encouraging the construction and refinement of schemata. For example, learners should be guided to integrate new programming concepts with their existing knowledge base, progressively building from basic syntax to more complex algorithmic thinking. Long-term memory plays a vital role in programming learning, as it contains existing schemata related to syntax, semantics, and programming plans—the foundational elements for solving programming tasks. Effective instructional designs should aim to modify and expand these existing schemata, enabling learners to integrate creativity into their approach to programming problems.

Creativity is particularly significant in programming as it fosters innovative solutions and novel approaches to challenges. However, the influence of creativity on learning is moderated by cognitive style. Analytical learners may excel in logically structuring and debugging programs, while intuitive learners might demonstrate strength in exploring new algorithms or design strategies. Tailoring instructional approaches to accommodate these cognitive styles ensures that learners can channel their creativity effectively without becoming cognitively overloaded.

Research on how creativity influences students' outcomes in computer science is an interesting area that needs further exploration due to the complex nature of creativity and the field of computer science (Sharmin, 2021). Lutfiani (2021) suggested that further studies are necessary to strengthen the findings on the influence of creativity on students' learning. Likewise, exploring how cognitive style moderates this relationship is a pivotal contribution to knowledge in programming learning.

A moderator variable (cognitive style), a third variable, is utilised to examine the strength of the connection between an independent variable (creativity) and a dependent variable (programming achievement). This influence must be established during moderation analysis, and the moderator and independent variables must not be causally related. It is often used in research to examine the conditions under which a particular relationship exists or changes. Therefore, this study determined how the learners' cognitive styles moderate the contribution of their creativity to programming learning in senior secondary schools.

RESEARCH OBJECTIVES AND HYPOTHESES

Research Objectives

The main objective of this study was to determine the moderating influence of cognitive style on the relationship between creativity and students' achievement in the programming aspect of senior secondary computer studies. In particular, the researcher:

1. Investigated the contribution of creativity to students' academic achievement in the programming aspect of senior secondary computer studies.
2. Examined the contribution of cognitive style to students' academic achievement in the programming aspect of senior secondary computer studies.
3. Examined the joint contribution of creativity and cognitive style to students' achievement in the programming aspect of senior secondary computer studies.
4. Determined the moderating influence of cognitive style on the contribution of creativity to students' achievement in the programming aspect of senior secondary computer studies.

Null Hypotheses

The following null hypotheses were formulated and tested at a 0.05 significance level to accomplish the set objectives:

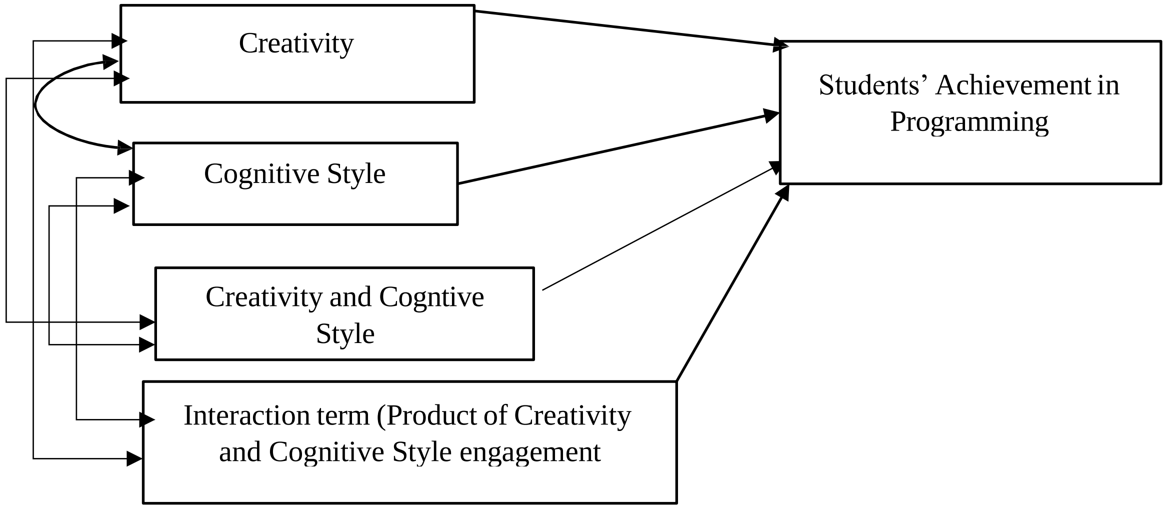
$H_0$1: There is no significant relative contribution of creativity to students' achievement in the programming aspect of senior secondary computer studies.
$H_0$2: There is no significant relative contribution of cognitive style to students' achievement in the programming aspect of senior secondary computer studies.
$H_0$3: There is no significant joint contribution of cognitive style and creativity to students' achievement in the programming aspect of senior secondary computer studies.
$H_0$4: There is no moderating influence of cognitive style on the relative contribution of creativity to students' achievement in the programming aspect of senior secondary computer studies.

METHODOLOGY

Research Design

The research design for this study was a descriptive survey. This enabled the researchers to explore and describe the linear and moderating relationship between creativity, programming achievement, and cognitive style in the context of senior secondary computer studies. The study model is shown in Figure 2.

Figure 2
Study Model for Creativity, Programming Achievement and Moderating Influence of Cognitive Style



Note. The model was conceived and drawn by the researcher of this study.

Figure 1 indicates that apart from finding the relative and joint contributions of creativity and cognitive style to the variance in students' programming learning, the contribution of the interaction term (moderating influence), which signifies the product of creativity and cognitive style, was also determined. While creativity is the independent variable, cognitive style is the moderating variable, and the dependent variable is students' achievement in programming.

Population and Sample

The target population for this study was the 1,352 senior secondary three (SS 3) students in public senior secondary schools in the Ikeja Local Government Area of Lagos State. The sample comprised two hundred and seventy (270) SS3 students offering Computer Studies selected from ten public senior secondary schools in Ikeja Local Government Area. Twenty-seven (27) students were randomly selected from each of the ten schools, amounting to a total of 270 participants from the ten schools, which were selected purposively on the criterion that they had computer teachers with B. Sc. (Ed.) in Computer Science/Education because programming teaching requires expertise, and only qualified computer teachers may be able to handle it effectively. The SS3 students were selected because they have enough programming cognitive entry behaviours and should have

.

Instruments

This research used the Students' Achievement Test in Programming (SATP), Programming Creative Style Inventory (PCSI), and Cognitive Style Inventory in Programming (CSI-P) for data collection. The SATP is a researcher-design test to measure students' programming knowledge. It consisted of 30 items from past questions from the West African Examinations Council (WAEC) exams. The content and face validities of the test were established through assessment by experts in computer science whose suggestions were harnessed to modify the instrument. The instrument's reliability was obtained by administering copies to twenty (20) SS 3 students in an unselected school with a qualified computer science teacher. The tests were conducted twice at an interval of 4 days. The test-retest statistics yielded a reliability coefficient of 0.74.

The Programming Creative Style (PCS) Inventory is a 30-item instrument with a four-option Likert Scale designed by researchers to determine students' creativity while engaging in programming tasks. The inventory was scored by summing up the ratings for all 30 items, with higher scores above the average rating of 60 points, indicating a greater tendency toward creative programming. The content and construct validities of the instrument were determined through the assessment of 3 experts in creativity in the Faculty of Education, Olabisi Onabanjo University (OOU). The researchers used their suggestions to modify the instrument further. Its reliability was found by administering it to 20 SS 3 students from an unselected school, and their responses were subjected to Cronbach Alpha statistics to determine the internal consistency of the instrument's items. It yielded a reliability coefficient of 0.76.

The Cognitive Style Inventory in Programming (CSI-P) is a 32-item, four-option Likert Scale adapted from Kirton's (1976) Adaption-Innovation Inventory to measure students' cognitive style along the adaptation-innovation continuum. The score above the midpoint symbolises Innovative cognitive style, while the score below indicates adaption. The content and face validities of CSI-P were established through the critiques of 3 experts in test construction in the Faculty of Education of OOU, and their suggestions were pooled together to modify the instrument. After that, 20 copies were administered to the same 20 SS 3 students of an unselected school who responded to the PCS, and their responses were subjected to Cronbach Alpha statistics to determine the internal consistency of the instrument's items. It yielded a reliability coefficient of 0.86.

Data Collection

Before administering the questionnaires and test, consent was obtained from the selected schools' authorities. In addition, students' informed consent was obtained after explaining the purpose of the questionnaires and test, how the information would be used, and a promise that the sources of information would be blinded. The questionnaire and test were administered to the students at a non-disruptive period. The researcher provided clear and comprehensive instructions to the students on how to complete the questionnaires and the test, and they were adequately supervised to ensure they followed the instructions and did not discuss responses with their classmates. After completing the instruments, they were collected and thoroughly reviewed to ensure all required information was included. Then, the questionnaires and tests were scored, and the results were recorded.

Data Analysis

For data analysis, inferential regression analysis statistics were employed to test the hypotheses at a 0.05 significance level using the Statistical Package for Social Sciences (SPSS) version 23. Testing the moderating Influence of a cognitive style on the relationship between creativity and cognitive style requires showing that the nature of the relationship between creativity and cognitive style changes with the change in cognitive style. This is achieved by adding the interaction term (product of creativity and cognitive style) in the model and inspecting if the addition brings a more significant contribution to the variance in programming achievement than without it. Specifically, the following steps were conducted:

1. All variables were standardised to avoid multicollinearity and to ease interpretation after analysis. This is achieved by centring the creativity and cognitive style data.
2. A dummy interaction term was calculated using centred creativity and cognitive style.
3. A regression model was fitted in block 1 to determine the contribution of creativity and cognitive style to the students' achievement in programming. To proceed, the contribution of creativity and cognitive style, as indicated by R^2, should be significant.
4. An interaction term was added to the previous model as block 2 and examined for significance. If both the R^2 change and the effect of the interaction terms are significant, then moderation is occurring. Meanwhile, complete moderation occurs when creativity and cognitive style are not significant when the interaction term is added.
5. Decision**:** If creativity and cognitive style are significant with the interaction term, moderation has occurred and has a significant main effect. However, SPSS does not provide conditional effects of the focal predictor at moderator levels. Therefore, the PROCESS macro by Andrew F. Hayes should be used to determine these effects if the R2 change is significant with the addition of the interaction term. (Uedufy, 2023).

RESULTS

The results are presented according to the descriptive analysis and hypotheses tested at the 0.05 significance level.

Descriptive Results

Table 1 presents the results for male and female students' achievement in programming, along with their respective cognitive styles and creativity in the subject. The dataset includes 130 male students and 140 female students.

Table 1

Respondents' Achievement Test, Cognitive Style and Creativity in Programming by Gender (N = 270)

Gender	n	Descriptive Statistics	Achievement in Programming	Cognitive Style in Programming	Creativity in Programming
Female	140	M	12.01	38.21	72.46
		SD	3.481	9.084	24.039
Male	130	M	12.12	37.34	67.78
		SD	3.629	9.310	24.483
Total	270	M	12.06	37.79	70.21
		SD	3.547	9.187	24.321

Table 1 shows that female students scored higher with a Mean =38.21, S.D.= 9.084 than their male colleagues with a Mean = 37.34, S.D. = 9.310 on the Cognitive Style Inventory. Similarly, female students obtained a higher mean score with a Mean = 72.46, S.D.=24.039 than the male students with a Mean = 67.78, S. D. = 24.483 in Programming Creativity, suggesting better adaptability and creativity in programming. The Achievement Test in Programming scores are nearly identical for both genders, with females having a mean achievement score of 12.01 and S.D.=3.481. In contrast, the males recorded a mean achievement score of 12.12 and S.D.= 3.692, indicating similar overall academic achievement in programming. The standard deviations are consistent across all categories, showing similar variability in scores for both genders.

Test of Hypotheses

$H_0$1: There is no significant relative contribution of creativity to students' achievement in the programming aspect of senior secondary computer studies.

Table 2

Contribution of Creativity to Students' Achievement in Programming

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	306.750	1	306.750	26.716	0.000[b]
	Residual	3077.179	268	11.482		
	Total	3383.930	269			
	R= 0.301; R^2= 0.091; Adjusted R^2= 0.087; Std Error = 3.389					

Table 2 indicates that the contribution of creativity to students' achievement in programming is significant, $F_{(1, 268)} = 26.716$, $p< 0.05$. The result shows that creativity contributed 9.1% to the variance in students' achievement in programming. Hence, the null hypothesis ($H_0$1) that creativity does not contribute significantly to students' achievement in the programming aspect of senior secondary computer studies is rejected.

$H_0$2: There is no significant relative contribution of cognitive style to students' achievement in the programming aspect of senior secondary computer studies.

Table 3

Contribution of Cognitive Style to Students' Achievement in Programming

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
	Regression	379.584	1	379.584	33.860	.000[b]
	Residual	3004.346	268	11.210		
	Total	3383.930	269			
	R= 0.335; R^2= 0.112; Adjusted R^2= 0.109; Std Error = 3.348					

Table 3 discloses that the contribution of cognitive style to students' achievement in programming is significant, $F_{(1, 268)}$ 33.860, $p< 0.05$. The result shows that creativity contributed 11.2% to the variance in students' achievement in programming. Hence, the null hypothesis ($H_0$2) that cognitive style does not contribute significantly to students' achievement in the programming aspect of senior secondary computer studies is rejected.

$H_0$3: There is no significant joint contribution of cognitive style and creativity to students' achievement in the programming aspect of senior secondary computer studies.

Table 4

Moderating Influence of Cognitive Style on Contribution of Creativity to Students' Achievement in Programming

					Change Statistics				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**R Square Change (ΔR^2)**	**F Change (ΔF)**	**df1**	**df2**	**Sig. F Change**
1	0.418	0.175	0.169	3.234	0.175	28.289	2	267	0.000
2	0.419	0.176	0.167	3.238	0.001	0.316	1	266	0.575

Table 5

Analysis of Variance on Moderating Influence of Cognitive Style on Contribution of Creativity to Students' Achievement in Programming

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	591.681	2	295.840	28.289	0.000
	Residual	2792.249	267	10.458		
	Total	3383.930	269			
2	Regression	594.989	3	198.330	18.916	0.000
	Residual	2788.940	266	10.485		
	Total	3383.930	269			

Model 1 Table 5 shows that creativity and cognitive style significantly contributed to students' achievement in programming, $F_{(2, 267)} = 28.289$, $p<0.05$. The results in Model 1, Table 5 indicate that creativity and cognitive style jointly contributed 17.5% of the variance in students' academic achievement. Thus, the null hypothesis ($H_0$3) that creativity and cognitive style do not jointly contribute significantly to students' achievement in the programming aspect of senior secondary computer studies is rejected.

$H_0$4: There is no moderating influence of cognitive style on the relative contribution of creativity to students' achievement in the programming aspect of senior secondary computer studies.

A hierarchical multiple regression analysis was conducted to test the hypothesis that there is no moderating influence of cognitive style on the relative contribution of creativity to students' achievement in the programming aspect of senior secondary computer studies. First, creativity and cognitive style were included, and their contribution was significant, $F_{(2, 267)} = 28.289$, $p<0.05$ (Model 1, Table 5). They jointly contributed 17.5% of the variance in students' academic achievement. Then, the creativity and cognitive style data were centred to avoid multicollinearity with the interaction term. After that, the interaction term was created (product of creativity and cognitive style based on centred data) (Aiken & West, 1991) and added to the regression model. The results in Model 2, Table 5 revealed a significant contribution of creativity, cognitive style, and the interaction term, $F_{(3, 266)}= 18.916$, $p<0.05$. According to results in Model 2, Table 4, they jointly contributed 17.6% of the variance in students' achievement in programming but $p>0.05$.

Further check on Table 4 shows that $\Delta R^2 = 0.001$, $\Delta F_{(1, 266)} = 0.316$, $p>0.05$. This outcome means that the contribution of 17.6% to variance to academic achievement in programming when the interaction term was added to the model is not significantly higher than the 17.5% contributed without the interaction term. The results, $\Delta R^2 = 0.001$ and $\Delta F_{(1, 266)} = 0.316$, $p > 0.05$, indicate no evidence of moderation influence of cognitive style on the relative contribution of creativity to students' achievement in programming. This outcome implies that the contribution of creativity to the variance in programming achievement is similar for students with adaptation and innovation cognitive styles. Hence, the null hypothesis (H_04) that there is no moderating influence of cognitive style on the relative contribution of creativity to students' achievement in the programming aspect of senior secondary computer studies is retained, and the Hayes process method is unnecessary.

DISCUSSION

This study was conceived to determine if cognitive styles moderate the contribution of creativity to students' programming learning. Four null hypotheses were formulated and tested at a 0.05 level of significance. One hypothesis was that there was no significant relative contribution of creativity to students' achievement in the programming aspect of senior secondary computer studies. However, the finding revealed that creativity significantly contributed to students' achievement in programming. This finding aligns with that of Sawaluddin, Syahbudin, Rido, and Ritonga (2022), who found that creativity significantly positively impacted students' learning outcomes at Madrasah Tsanawiyah NurulYaqin, Pekanbaru. It also concurs with the findings from the systematic literature review by Lutfiani (2021), which concluded that creativity significantly influenced students' achievement because creative ways of instructional delivery encourage students' absorption of the lesson materials. Conversely, the finding is at variance with that of Saka et al. (2021), which revealed no significant effect of creativity on students' programming learning.

The finding on the significant contribution of creativity to students' programming learning is not surprising because programming is a creativity enterprise with no one correct answer, and it is about generating many ideas that work to solve a given problem. Hence, creativity is a must-have skill for learners to write effective computer programs. In addition, the finding that 9.1% of the variance in students' achievement in programming is heartwarming. This outcome suggests that creativity is a potent factor in determining students' learning of computer programming. It also means that creativity can help learners reduce extraneous cognitive load by making the material more engaging and exciting, which makes them focus on the task at hand and avoid getting lost. This finding aligns with that of Ugur (2023), who examined the effects of creativity on students' academic achievement through a meta-analytical approach and reported a significant role of creativity in learning.

Similarly, the study guessed tentatively that cognitive style has no significant relative contribution to students' achievement in the programming aspect of senior secondary computer studies. The finding, however, indicated that the contribution of cognitive style to students' achievement in programming is significant. This finding agrees with that of Ifelunni et al. (2022), who explored cognitive styles as predictors of academic achievement among students in South East Nigeria and reported a significant relationship between cognitive style and academic performance. It also resonates with that of Eriba et al. (2021), who showed a significant effect of cognitive style on students' academic achievement and recommended that teachers strive for instructional strategies favouring learners' diverse cognitive styles. This finding connotes that cognitive style, the way students process and understand information, impacts programming learning. It can help reduce extraneous cognitive load when materials are presented in a way that is compatible with the learner's cognitive style because learners have fewer cognitive resources to process the information. This may explain why learning programming is complicated for some students and more accessible for others. Based on this finding, teachers should deliver classroom instruction to cater to the various learners' cognitive styles because doing this will make learning more attractive to them.

In an attempt to determine the moderating influence of cognitive style on the contribution of creativity to students' programming learning, it was hypothesised that there was no significant joint contribution of cognitive style and creativity to students' achievement in the programming aspect of senior secondary computer studies. However, the study found that cognitive styles and creativity jointly contributed significantly to students' programming learning. This shows that both variables are potent factors that should be given a premium in learning computer programming. The finding that creativity and cognitive style jointly contributed 17.5% of the variance in students' academic achievement means that these variables accounted for about 17.5% of their achievement in programming. Thus, curriculum developers and teachers should always factor these variables in preparing curriculum and lesson delivery to create an enduring learning experience for the learners.

Meanwhile, with the interaction term added to the regression analysis, the study found that the contribution of the product of creativity and cognitive style was insignificant. It only accounted for 17.6%, implying no evidence of a significant moderating influence of students' cognitive type on how their creativity contributes to achievement in programming. This finding further suggests that the contributions of creativity to achievement in programming learning of students with adaptation and innovation cognitive styles are similar. These findings contradict Zhou et al. (2016), who stated that cognitive style moderated the relationship between creativity and academic achievement, such that intuitive students who were also creative had higher academic achievement than intuitive students who were not creative. They also vary with Oztunc (2013), that cognitive style moderated the relationship between individuals with creative potential and creative performance. A plausible explanation for the outcome is that cognitive style may not have the power to moderate the relationship between creativity and achievement in programming because cognitive style does not significantly determine what a learner achieves in programming once they are creative. Another reason may be due to the sample size of this study, which is 270 participants. With a large number of participants, enough statistical power may be produced to detect a significant interaction effect. Similarly, the interaction effect may be weak, which may improve even when the sample size increases.

The findings of this study are deeply rooted in Cognitive Load Theory (CLT), which provides a framework for understanding how creativity and cognitive style influence students' programming learning by managing cognitive resources effectively during the learning process. The significant contribution of creativity to students' programming achievement aligns with CLT's emphasis on minimizing extraneous cognitive load while enhancing germane cognitive load. Programming inherently involves solving complex problems with no single correct answer, requiring creativity to generate innovative solutions. Creativity allows students to engage deeply with programming tasks, making the material more interesting and reducing distractions. This helps learners focus their cognitive resources on essential aspects of the task, fostering schema construction and refinement as they integrate new programming concepts into their existing knowledge.

Cognitive style also significantly contributes to programming achievement, as demonstrated in this study, further underscoring its relevance to CLT. Cognitive style determines how learners process and understand information, influencing their ability to allocate cognitive resources effectively. Instructional materials designed to align with a learner's cognitive style—whether adaptive (structured and rule-based) or innovative (exploratory and creative)—help reduce extraneous cognitive load by minimizing mismatches between the information presentation and the learner's preferred processing style. Cognitive style frees up working memory capacity by reducing extraneous load, enabling learners to focus on germane loads, such as refining their understanding of programming concepts. Moreover, the study revealed that creativity and cognitive style jointly contributed significantly to programming learning, accounting for 17.5% of students' programming achievement variance. This suggests that combining creative approaches with instructional designs that align with cognitive styles creates a supportive learning environment. Another finding indicates that creativity contributes to programming achievement similarly across different cognitive styles. Regarding CLT, creativity's role in reducing extraneous load and enhancing germane load appears universal, irrespective of individual differences in cognitive style.

These findings have critical implications for programming education. Teachers should prioritize fostering creativity through open-ended problem-solving tasks and opportunities for students to experiment with multiple solutions. At the same time, instructional materials should be designed to accommodate diverse cognitive styles, ensuring all learners can effectively engage with and process the content. By doing so, educators can optimize cognitive load distribution, enabling students to maximize their learning potential.

Curriculum developers should also integrate creativity and cognitive style as core components of programming education. Designing curricula that emphasize both adaptive and innovative problem-solving alongside tailored instructional approaches can create enduring learning experiences that prepare students for the demands of programming and other creative problem-solving domains. Ultimately, this study underscores the importance of balancing cognitive loads through creativity and cognitive style, aligning with the principles of Cognitive Load Theory to enhance programming learning outcomes.

CONCLUSIONS

The objective of this study was to determine if cognitive style moderates the contribution of creativity to students' learning in programming for effective contribution to the AI-dominated economy. It was established that creativity and cognitive style both contribute significantly to students' programming learning. However, there was no evidence of a significant moderating influence of cognitive style on the contribution of creativity to achievement in programming. This result suggests that the contributions of creativity to achievement in programming learning of students with adaptation and innovation cognitive styles are similar. The implication of this finding to teaching practice is that teachers should always devise methods of improving learners' creativity. This can be ensured by giving them essay questions that will be thought-provoking instead of multiple-choice, which depends most of the time on guesswork.

Based on these findings, the study recommends that curriculum developers and teachers always factor in creativity and cognitive style when preparing curriculum and lesson delivery to create an enduring learning experience for the learners. This finding beckons the teachers to enhance learners' creativity to improve their programming learning, which will, in turn, prepare them to contribute to constructing AI tools. It is also suggested that teachers deliver classroom instruction to cater to the various learners' cognitive styles because doing this will make learning more attractive. Further research is needed to investigate the moderating influence of cognitive style on the contribution of creativity to achievement in programming with a larger sample size.

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REFERENCES

Adeyanju, T. A., & Adewale, O. A. (2021). Factors influencing students' interest and motivation in learning programming in Nigeria. *International Journal of Education and Development using Information and Communication Technology (IJEDICT), 17*(1), 1-12. https://doi.org/10.18844/ijedict.2021.17.1.1

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, Sage

Akinola, S. O. (2016). Computer programming skills and gender difference: An empirical Study. *American Journal of Scientific and Industrial Research*, 7(1), 1-9. https://doi.org/10.5251/ajsir.2016.7.1.1.9

Beghetto, R. A., & Kaufman, J. C. (2014). Classroom contexts for creativity. *High Ability Studies*, 25(1), 53-69. https://doi.org/10.1080/13598139.2014.905247

Chuang, T. Y., Yeh, M. K. C., & Lin, Y. L. (2021). The impact of game playing on students' reasoning ability varying according to their cognitive style. *Educational Technology & Society*, *24*(3), 29–43.

Eriba, J. O., Garba, J. A., Adejoh, M. J., & Okwara, O. K. (2021). Effects of cognitive styles and collaborative instructional strategy on academic achievement of senior secondary chemistry students in Benue State, Nigeria. *VillageMath Educational Review*, *2*(1), 119–131. https://doi.org/10.5281/zenodo.5526267

Federal Ministry of Communication Technology. (2012). *National Information and Communication Technology (ICT) Policy*. https://researchictafrica.net/countries/nigeria/Nigeria_National_ICT_Policy_(draft)_2012.pdf

Federal Ministry of Education. (2017). *Education for change: A ministerial strategic plan (2018-2019)*. https://education.gov.ng/wp-content/uploads/2019/03/FINAL- UPDATED-MSP-WITH-COSTING.pdf

Fredagsvik, M. S. (2021). The challenge of supporting creativity in problem-solving projects in science: A study of teachers' conversational practices with students. *Research in Science & Technological Education*, *0*(0), 1–17. https://doi.org/10.1080/02635143.2021.1898359

Furman, J., & Seamans, R. (2019). AI and the economy. *Innovation Policy and the Economy*, 19(1), 161-191. https://doi.org/10.1086/699936

Garcia, M. B., & Revano, T. F. (2021). Assessing the role of Python programming gamified course on students' knowledge, skills performance, attitude, and self-efficacy. *2021 IEEE 13th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*, 1–5. https://doi.org/10.1109/HNICEM54116.2021.9731935

Garner, S. (2002). Reducing the Cognitive Load on Novice Programmers. In P. Barker & S. Rebelsky (Eds.), *Proceedings of ED-MEDIA 2002--World Conference on Educational Multimedia, Hypermedia & Telecommunications* (pp. 578-583). Association for the Advancement of Computing in Education (AACE).

Hamzah, A. N., & Baa, S. (2022). The relationship between cognitive styles and English productive skills of vocational high school students in Makassar. *IDEAS: Journal on English Language Teaching and Learning, Linguistics and Literature*, *10*(1), Article 1. https://doi.org/10.24256/ideas.v10i1.2742

Henriksen, D., Mishra, P., & Fisser, P. (2016). Infusing creativity and technology in 21st century education: A systemic view for change. *Journal of Educational Technology & Society*, *19*(3), 27–37.

Ifelunni, C. O., Ezema, R. F., Victor, S., Ugwu, G. C., Eze, R. F., Celestine, O., & Ncheke, D. C. (2022). Cognitive styles as a correlate of pupils' academic achievement in South-East, Nigeria. *International Journal of Social Science And Human Research*, *5*(1), 159–166. https://doi.org/10.47191/ijsshr/v5-i1-24

Janah, S. R., Suyitno, H., & Rosyida, I. (2021). Mathematics critical thinking skills reviewed by cognitive styles and iq on discovery learning with SPUR approach. *Unnes Journal of Mathematics Education Research*, *10*(A), 35–41.

Kirton, M. J. (1976). Adaptors and innovators: A description and measure. *Journal of Applied Psychology*, 61(5), 622–629. https://doi.org/10.1037/0021-9010.61.5.622

Kirton, M. J. (2003). *Adaption-Innovation: In the context of diversity and change.* Routledge.

Lutfiani, U. (2021). Effect of creativity on student learning achievement. *Psikoeduko: Jurnal Psikologi Edukasi Dan Konseling*, *1*(1), 1–9. https://doi.org/10.17509/psikoeduko.v1i1.32827

Mertayasa, I. N. E., Subawa, I. G. B., Agustini, K., & Wahyuni, D. S. (2021). Impact of cognitive styles on students' psychomotor abilities on multimedia course practicum. *Journal of Physics: Conference Series*, *1810*(1). https://doi.org/10.1088/1742-6596/1810/1/012056

Mhlanga, D. (2021). Artificial Intelligence in Industry 4.0, and Its Impact on Poverty, Innovation, Infrastructure Development, and the Sustainable Development Goals: Lessons from Emerging Economies? *Sustainability*, 13, 5788. https://doi.org/10.3390/SU13115788 .

Nofrialdi, R. (2022). The effect of student's creativity and learning interest on learning achievement in economic students class xi IPS SMA EKASAKTI PADANG. *Journal International on Global Education*, *1*(1), 37–46. https://doi.org/10.31933/jige.v1i1.536

Odo, C. R. & Odo, I. A. (2016). Effect of simulation on students' interests in programming language of secondary schools in Enugu Education Zone of Nigeria. *International Journal of Information and Educational Technology,* 6(6), 447-480. https://doi.org/10.7763/IJIET.2016.V6.735

Oyelami, M. O., Oyebisi, L. O., & Afolayan, J. O. (2017). Assessment of secondary school students' performance in computer programming in Osun State, Nigeria. *Journal of Information Technology and Economic Development*, 8(1), 35-49.

Oztunc, G. (2013, December 1). *Examining the moderating effects of affective, cognitive, and personality factors on the relationship between creative potential and creative performance*. https://getd.libs.uga.edu/pdfs/oztunc_gokhan_201312_phd.pdf

Prakoso, B. H., Ramdani, Z., & Tae, L. F. (2021). Creativity, critical thinking, and academic performance in students university during virtual learning. *International Conference on Educational Assessment and Policy (ICEAP 2020)*, *545*, 156–162. Atlantis Press. https://doi.org/10.2991/assehr.k.210423.081

Richardson, C., & Mishra, P. (2018). Learning environments that support student creativity: Developing the scale. *Thinking Skills and Creativity*, *27*, 45–54. https://doi.org/10.1016/j.tsc.2017.11.004

Saetra, H. (2020). A shallow defence of technocracy of Artificial Intelligence: Examining the political harms of algorithmic governance in the domain of government. *Technology in Society*, 62, 101283 - 101283. https://doi.org/10.1016/j.techsoc.2020.101283.

Saka, A. O. (2020). Learning to write program using think-pair-share programming strategy: what are the students' perceptions and experiences? *Journal of Educational Sciences*, 4(4), 705-717. https://doi.org/10.31258/jes.4.4.p.705-717.

Saka, A. O., Ifamuyiwa, A. S., & Erinosho, S. Y. (2021). Effect of think-pair-share programming strategy and creativity on senior secondary school students' achievement in programming aspect of computer studies. *Journal of the Science Teachers Association of Nigeria*, 56, 142-152. https://doi.org/10.31258/jes.4.4.p.705-717

Sawaluddin, S., Syahbudin, K., Rido, I., & Ritonga, S. (2022). Creativity on student learning outcomes in al-quran hadith subjects. *Journal of Innovation in Educational and Cultural Research*, *3*(2), 257–263. https://doi.org/10.46843/jiecr.v3i2.106

Sharmin, S. (2021). Creativity in CS1: A literature review. *ACM Transactions on Computing Education (TOCE)*. https://doi.org/10.1145/3459995

Smirnov, E., & Lukyanov, S. (2019). Development of the Global Market of Artificial Intelligence Systems. *Economy of Region*, 1(1), 57-69. https://doi.org/10.17059/2019-1-5.

Sun, D., Ouyang, F., Li, Y., & Zhu, C. (2021). Comparing learners' knowledge, behaviors, and attitudes between two instructional modes of computer programming in secondary education. *International Journal of STEM Education*, *8*(1), 54. https://doi.org/10.1186/s40594-021-00311-1

Taheri, M., Falahchai, M., Javanak, M., Hemmati, Y. B., & Bozorgi, M. D. (2021). Analysing the relationship between learning styles (Kolb and VARK) and creativity with the academic achievement of dental students. *Journal of Education and Health Promotion*, *10*, 252. https://doi.org/10.4103/jehp.jehp_1492_20

Uedufy (2023, March 24). *How to Perform Moderation Analysis in SPSS [2 Methods]*. https://uedufy.com/how-to-perform-moderation-analysis-in-spss/ .

Unique, U. (2021, June 8). *Why coding is important in 21st Century*. https://umeshunique.medium.com/why-coding-is-important-in-21st-century-300b0e8d4d26

West African Examinations Council, (2015). *General comments*. https://www.waeconline.org.ng/e-learning/Computer/Comp324mc.html

West African Examinations Council, (2016). *General Comment*. https://www.waeconline.org.ng/e-learning/Computer/Comp325mc.html

West African Examinations Council, (2017). *General comments.* https://www.waeconline.org.ng/e-learning/Computer/Comp326mc.html

West African Examinations Council, (2018). *General comments*. https://www.waeconline.org.ng/e-learning/Computer/Comp327mc.html

West African Examinations Council, (2019). *General comments*. https://www.waeconline.org.ng/e-learning/Computer/Comp328ms.html

Wulanningtyas, N. D., & Fauzan, F. (2022). The influence of creativity and learning motivation on students' learning independence with friend support as moderating variables. *International Journal of Social and Management Studies*, *3*(1), 196–207. https://doi.org/10.5555/ijosmas.v3i1.99

Yeldham, M., & Gao, Y.-J. (2021). Examining whether learning outcomes are enhanced when L2 learners' cognitive styles match listening instruction methods. *System*, *97*, 102435. https://doi.org/10.1016/j.system.2020.102435

Zhou, X., Chen, Z., & Zhang, L. (2016). The moderating role of cognitive style in the relationship between creativity and academic achievement: A study of elementary school students in China. *Thinking Skills and Creativity*, 21, 10-20.