



Unveiling the Dynamics of AI-Enhanced Digital Learning: Interlinking Anxiety, Learning Styles and Home Environment in Shaping Future-Ready Students

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Abstract

In the current era of rapid technological transformation, artificial intelligence (AI) has emerged as a powerful catalyst for educational innovation, enabling adaptive, interactive, and personalized learning experiences. The present study examines the relationship between AI-enhanced digital learning engagement and academic achievement among senior secondary students, and further explores the influence of academic anxiety, learning styles, and home environment. A correlational research design was adopted, and data were collected from a stratified random sample of 120 students (60 male and 60 female students) studying in government and private schools in Rohtak, Haryana. Standardized tools were used to measure academic anxiety, learning styles, and home environment, along with a researcher-developed AI-Integrated Digital Learning Engagement (AIDLE) Scale. Academic achievement scores were obtained from official school records. Results indicated significant positive correlations of AI-enhanced digital learning with academic achievement ($r = .57, p < .01$) and home environment ($r = .52, p < .01$), while academic anxiety showed a significant negative correlation ($r = -.46, p < .01$). Regression analysis further revealed that AIDLE engagement and home environment significantly predicted academic performance. The study concludes that integrating AI into learning, supported by a positive home environment and effective management of academic anxiety, can promote the development of future-ready learners capable of thriving in the digital age. The findings have implications for designing AI-based personalized learning environments in Indian secondary education.

Keywords: Academic anxiety, AI in education, digital learning, home environment, learning styles.

Introduction

Academic achievement is one of the most critical indicators of educational success, encompassing not only the mastery of cognitive skills but also the development of socio-emotional and adaptive competencies (UNESCO, 2015; Ryan & Deci, 2020). In India, senior secondary schooling represents a decisive phase that shapes students' access to higher education, employability, and long-term career pathways. However, this phase often coincides with intense academic pressure, examination stress, and unequal learning outcomes (National Council of Educational Research and Training [NCERT], 2020). Therefore, understanding the multifaceted factors influencing academic performance is crucial for educators, researchers, and policymakers committed to fostering holistic student development.

Among the psychological variables that significantly affect scholastic outcomes, academic anxiety has consistently been identified as a major impediment to effective learning. High levels of anxiety can impair concentration, working memory, and confidence, thereby diminishing learning efficiency and test performance (Spielberger, 1972; Malik *et al.*, 2023).

While moderate anxiety may motivate some learners, excessive or chronic anxiety often leads to avoidance behaviors, procrastination, and cognitive overload, ultimately reducing academic engagement (Yerkes & Dodson, 1908).

Equally important are learning styles, which reflect individuals' preferred modes of acquiring, processing, and retaining information, whether visual, auditory, kinesthetic, or multimodal (Kolb, 1984; Sternberg, 1994; Sharma & Verma, 2024). When instructional approaches align with students' cognitive preferences, learners often demonstrate higher motivation, deeper understanding, and improved academic performance. Conversely, mismatches between teaching methods and learning styles may result in reduced engagement and lower achievement.

The home environment also serves as a vital contextual factor influencing student outcomes. Beyond providing material resources, it encompasses emotional support, parental involvement, and structured routines. A nurturing and organized home atmosphere fosters discipline, motivation, and psychological stability, which collectively enhance learning and achievement (Bloom, 1981; Henderson & Berla,

1994; Singh & Kumar, 2023). In contrast, homes characterized by conflict, limited support, or poor academic stimulation may increase stress and hinder academic growth (Desforges & Abouchaar, 2003).

In recent years, the rapid integration of digital technologies and artificial intelligence (AI) in education has introduced new paradigms of personalized learning. AI-Integrated Digital Learning Engagement (AIDLE) is a multidimensional construct encompassing cognitive, emotional, and behavioral involvement in AI-supported learning environments, including intelligent tutoring systems, adaptive simulations, and AI-driven feedback platforms (Holmes *et al.*, 2019; Chen *et al.*, 2024; Tan & Li, 2023). These systems enable individualized learning pathways, real-time feedback, and interactive problem-solving opportunities, allowing students to learn at their own pace while addressing variations in cognitive preferences and reducing anxiety.

Despite global advancements in AI-mediated learning, empirical research in India examining the combined influence of AI-based learning engagement, psychological variables, and home environment remains limited (Kundu & Bej, 2021). Most previous studies have focused on isolated factors rather than analyzing their interaction within technologically enriched learning environments.

Therefore, the present study aims to bridge this research gap by investigating how AI-enhanced digital learning interacts with academic anxiety, learning styles, and home environment to influence academic achievement among senior secondary students in Rohtak, Haryana. By examining these interrelated dimensions, the study contributes to the evolving discourse on technology-driven, psychologically informed, and contextually grounded educational practices that nurture competent and adaptive learners prepared for contemporary academic demands.

Significance of the Study

The present study is significant in the evolving educational landscape where artificial intelligence (AI) is transforming teaching and learning processes. It contributes to the emerging body of research examining how AI-enhanced digital learning interacts with psychological and environmental factors to influence students' academic performance. By integrating constructs such as academic anxiety, learning styles, and home environment, the study offers a comprehensive understanding of the multi-dimensional determinants of learner outcomes in technology-driven classrooms.

The findings hold practical value for teachers, school leaders, and policymakers working toward the goals of India's National Education Policy (NEP, 2020), which emphasizes learner-centered, inclusive, and technology-integrated education. The study also highlights the critical role of emotional support and parental involvement, underscoring that the benefits of AI-based learning can be maximized only when supported by a positive home environment and students' psychological well-being. Overall, the study provides evidence that effective integration of AI in education requires a balanced focus on technology, pedagogy, and student support systems to foster competent and adaptive learners.

Review of Literature

Theoretical and Empirical Foundations

Academic achievement results from the combined influence of psychological, cognitive, and environmental factors. At the

senior-secondary stage, three dimensions repeatedly emerge as key determinants: academic anxiety, learning styles, and the home environment. Prior studies show that these variables not only exert independent effects but also interact dynamically to shape students' learning trajectories. Understanding their interconnected roles is essential for developing evidence-based educational practices.

Home Environment and Academic Achievement

The home environment forms the first and most enduring context for a learner's development. Supportive homes characterized by parental involvement, emotional warmth, and access to learning resources create favorable conditions for sustained engagement and motivation (Adeyemo, 2012; Ahmad *et al.*, 2011; Bakar & Usaini, 2015). Evidence from both Indian and international studies confirm that a structured and nurturing family climate strengthens self-discipline, resilience, and achievement motivation among adolescents (Benipal & Singh, 2014; Dhingra & Manhas, 2009; Kumar & Mandal, 2013).

Conversely, households marked by neglect, inconsistent routines, or limited supervision are associated with lower self-efficacy and reduced academic outcomes (Ojha, 2007; Ullah & Hussain, 2013; Okeke, 2014). The quality of the parent-child relationship mediates the effect of family climate on academic behavior and stress regulation (Saraswathi, 2001; Nair & Pillai, 2014; Burke & Fedorek, 2017).

Parental nurturance, positive communication, and consistent reward systems foster autonomy and intrinsic motivation, whereas punitive or rejecting practices heighten anxiety and disengagement (Choudhary, 2010; Khan, 2014). These findings align with Bronfenbrenner's ecological theory (1979) and Epstein's (1995) model of school-family partnerships, which position the home as a foundational microsystem influencing academic development.

Learning Styles and Academic Achievement

Learning styles refer to individuals' preferred ways of perceiving, processing, and retaining information. Alignment between instructional methods and learners' preferences enhances motivation and academic performance (Aggarwal, 2011; Almigbal, 2015; Babu, 2015).

Students who are aware of their learning styles can employ metacognitive strategies that improve comprehension and problem-solving abilities (Arya, 2014; Vaishnav, 2013). Research supports that multimodal and experiential instructional approaches incorporating visual, auditory, and kinesthetic elements improve retention and reduce cognitive load (Al-Hebaishi, 2012; Aggarwal, 2002).

Conversely, when teaching methods conflict with learners' cognitive preferences, reduced motivation and cognitive dissonance may occur (Bhardwaj & Gupta, 2006; Kaur & Gill, 2011). Hence, designing pedagogy that accommodates diverse learning styles is central to achieving equitable and personalized learning specially within AI-supported systems.

Anxiety and Academic Achievement

Among emotional determinants, academic anxiety plays a prominent role. Elevated anxiety disrupts attention, working memory, and problem-solving abilities, thereby impairing performance (Allgulander, 1997; Di Gallo *et al.*, 1997).

Indian studies consistently report a negative correlation between test anxiety and scholastic achievement (Deb & Walsh, 2010; Halder & Mishra, 2014; Yadav & Misra, 2016). Supportive home contexts can buffer these effects; students

from emotionally stable families tend to exhibit lower anxiety and better academic adjustment (Khatoon & Mahmood, 2010; Qureshi, 2015).

According to Cognitive Appraisal Theory (Lazarus & Folkman, 1984), anxiety arises when perceived demands exceed coping resources. Interventions such as mindfulness, resilience training, and self-regulation practices have been shown to reduce anxiety and enhance academic performance (Dweck, 2006; Goleman, 1995).

Interrelationship among Home Environment, Learning Styles, and Anxiety

Recent literature indicates that these three domains operate interactively rather than independently. Supportive home settings can moderate the negative influence of anxiety by enhancing self-efficacy and emotional stability, while instruction aligned with learning styles can buffer stress and strengthen engagement (Desforjes & Abouchaar, 2003; Subramanian, 2014).

Holistic investigations (Malhotra, 2003; Sharma & Yadav, 2018) demonstrate that emotional security, instructional compatibility, and environmental stability collectively produce higher levels of academic achievement, supporting an ecological model that integrates cognitive, emotional, and contextual systems.

Emerging Perspectives: AI and Digital Learning Integration

The digital revolution has transformed educational delivery, positioning artificial intelligence (AI) as a catalyst for personalized, adaptive, and data-driven learning. AI-enhanced platforms provide real-time feedback; learner analytics, and adaptive content, thereby enabling responsive learning ecosystems that honor individual learning differences and help reduce anxiety (Chen *et al.*, 2024; Tan & Li, 2023).

These systems also strengthen school-home collaboration, allowing parents and teachers to monitor progress and emotional well-being more effectively (Henderson & Mapp, 2002; Harris & Goodall, 2008).

Despite these advancements, Indian research examining how AI-based learning interacts with psychological and environmental variables remains limited. The present study addresses this gap by analyzing the combined effects of academic anxiety, learning styles, and home environment within AI-integrated learning contexts.

Research Gap Identified

Although numerous studies have examined the influence of academic anxiety, learning styles, and home environment on students' academic performance, most prior investigations have treated these factors independently. Very few have explored their combined effects within the context of AI-integrated digital learning, particularly in the Indian secondary education system. This represents a critical gap in the literature, as technology-driven learning environments are rapidly reshaping the educational landscape and altering traditional teacher-student-home dynamics. Addressing this gap is essential to understand how psychological and contextual variables interact to determine learning outcomes in digital settings. The present study addresses this gap by empirically examining how AI-enhanced learning, supported by diverse learning styles and home environments, influences academic achievement and academic anxiety among senior secondary students in Rohtak, Haryana.

Research Objectives

Grounded in the review of literature and the identified research gap, the present study aims to explore the interrelationship among psychological, cognitive, and environmental factors influencing students' academic achievement within AI-enhanced digital learning environments.

The specific objectives are:

- i). To examine the relationship between academic achievement and the variables of academic anxiety, learning styles, home environment, and AI-enhanced digital learning engagement among senior secondary school students in Rohtak, Haryana.
- ii). To compare the academic achievement of male and female students with respect to their levels of academic anxiety, learning styles, home environment, and AI-based learning engagement.
- iii). To analyze the combined effect of academic anxiety, learning styles, home environment, and AI-enhanced digital learning on overall academic performance.
- iv). To identify possible differences in academic achievement between students from government and private schools concerning anxiety, learning preferences, home environment, and AI-based learning engagement.
- v). To explore the predictive strength of academic anxiety, learning styles, home environment, and AI-integrated digital learning engagement for explaining variance in students' academic achievement.

Research Hypotheses

To empirically validate the objectives, the following null (H_0) and alternative (H_1) hypotheses were formulated:

H_{01} : There is no significant relationship between academic achievement and academic anxiety, learning styles, home environment, and AI-enhanced digital learning engagement among senior secondary students.

H_{11} : There is a significant relationship between these variables.

H_{02} : There is no significant difference in academic achievement between male and female students with respect to academic anxiety, learning styles, home environment, and AI-based learning engagement.

H_{12} : There is a significant difference between male and female students on these variables.

H_{03} : There is no significant association between academic achievement and each dimension of anxiety, learning styles, home environment, and AI-based learning engagement across gender groups.

H_{13} : There is a significant association between academic achievement and each dimension of these variables across gender groups.

H_{04} : There is no significant difference in the academic achievement of students studying in private and government schools.

H_{14} : There is a significant difference between students from private and government schools.

H_{05} : There is no significant relationship between academic achievement and academic anxiety, learning styles, home environment, and AI-enhanced digital learning engagement when analyzed separately for school type (government vs. private).

H_{15} : There is a significant relationship between these variables across school types.

Research Design and Methodology

Research Design: The present study adopted a correlational research design to explore the interrelationships among academic anxiety, learning styles, home environment, and AI-enhanced digital learning engagement in predicting students' academic achievement. This design was chosen because it enables the examination of relationships among naturally occurring variables without experimental manipulation (Best & Kahn, 1997). The study aimed to describe existing conditions and analyze the extent to which selected psychological and environmental factors contribute to variations in students' achievement.

Variables of the Study

- **Dependent Variable:** Academic achievement (percentage scores obtained in the latest annual or board examinations).
- **Independent Variables:** Academic anxiety; Learning styles (Enactive, Figural, Verbal); Home environment; AI-Enhanced Digital Learning Engagement (AIDLE).

Population and Sample

The population comprised students enrolled in Classes XI and XII from government and private senior secondary schools in Rohtak district, Haryana. Using a stratified random sampling technique, a total of 120 students (60 boys and 60 girls) were selected to ensure balanced representation across gender and school type. The sample included 60 students each from government and private schools. The chosen sample size was considered adequate for correlational and comparative analyses, ensuring sufficient statistical power while maintaining research feasibility.

Tools and Instruments Used

To ensure methodological rigor, standardized instruments with established reliability and validity were employed:

- **Comprehensive Anxiety Scale (Sinha & Sinha, 2002):** Measures physiological and psychological components of academic anxiety. Reliability: $\alpha = .86$; Validity: .72.
- **Learning Style Inventory (Mishra, 2012):** Identifies three dominant learning preferences: Enactive, Figural, and Verbal. Reliability range: .68–.90.
- **Home Environment Inventory (Mishra, 2012):** Consists of 100 items across ten dimensions, including nurturance, control, reward, and punishment. Reliability: .72–.94.
- **AI-Integrated Digital Learning Engagement (AIDLE) Scale (Self-constructed):** Developed by the researcher to measure cognitive, emotional, and behavioral engagement in AI-supported learning contexts. The scale was validated through expert review and pilot testing; Cronbach's $\alpha = .82$. (See Appendix for sample items.)
- **Academic Achievement:** Measured using students' aggregate marks (%) obtained in their most recent annual or board examinations, verified from official school records.

Data Collection Procedure

Data collection was conducted in adherence to ethical and procedural standards. Permission was obtained from school principals and district education authorities. Participants were briefed about the purpose, confidentiality, and voluntary nature of the study. All tools were administered under standardized conditions during regular school hours. Responses were scored according to manual instructions, and

data were compiled in an Excel sheet for analysis. Academic scores were verified from official school records to ensure objectivity. This systematic approach ensured ethical compliance, accuracy, and reliability of the data.

Statistical Techniques Used

Both descriptive and inferential statistics were applied using IBM SPSS Statistics 25.0.

Descriptive Statistics: Mean, standard deviation, and frequency distributions were computed to summarize sample characteristics and variable trends.

Inferential Statistics: Pearson's product-moment correlation (r) to assess relationships among variables; independent-samples t -tests to compare gender and school-type differences; one-way ANOVA to examine group differences across learning style dimensions; and multiple regression analysis to identify the combined predictive power of anxiety, learning styles, home environment, and AIDLE engagement. Statistical significance was tested at $p < .05$ and $p < .01$.

The study adhered to ethical standards in educational research. Informed consent was obtained from all participants. Confidentiality of responses and academic data was maintained. Data were used solely for academic purposes, and no identifying information was disclosed.

Results

Descriptive Statistics of the Study Variables

Descriptive statistics were computed to summarize the central tendency and variability of academic anxiety, learning styles, home environment, AI-enhanced digital learning engagement (AIDLE), and academic achievement.

Table 1: Descriptive Statistics of the Study Variables (N = 120)

Variable	Mean	SD
Academic Anxiety	48.63	9.24
Learning Styles (Composite)	63.45	8.17
Home Environment	72.81	10.32
AIDLE Engagement	68.74	7.88
Academic Achievement (%)	74.56	8.90

Note: Higher scores indicate greater levels of the corresponding variable.

The results show that students scored moderately high on AI-based learning engagement and home environment, while academic anxiety remained at a moderate level. The mean academic achievement score ($M = 74.56$, $SD = 8.90$) reflects satisfactory overall performance among participants.

Relationships among Key Variables

To examine the degree of association among the major variables, Pearson's Product-Moment Correlation coefficients were computed. The findings are summarized in Table 2.

Table 2: Correlation Matrix among Academic Anxiety, Learning Styles, Home Environment, AIDLE Engagement, and Academic Achievement

Variables	1	2	3	4	5
Academic Anxiety	—				
Learning Styles	-.24*	—			
Home Environment	-.38**	.42**	—		
AIDLE Engagement	-.31**	.49**	.54**	—	
Academic Achievement	-.46**	.44**	.52**	.57**	—

* $p < .05$, ** $p < .01$

The correlation results reveal that academic anxiety was negatively correlated with academic achievement ($r = -.46, p < .01$), indicating that students with higher anxiety levels tended to perform less effectively. In contrast, learning styles, home environment, and AIDLE engagement were positively correlated with academic achievement (r values ranging from .44 to .57, $p < .01$). These findings highlight the multifactorial nature of achievement, showing that both psychological and contextual factors significantly influence student outcomes.

Predictors of Academic Achievement

To determine the combined influence of academic anxiety, learning styles, home environment, and AIDLE engagement on academic achievement, a multiple regression analysis was performed. The results are presented in Table 3.

Table 3: Multiple Regression Analysis Predicting Academic Achievement (N = 120)

Predictor Variables	B	SE B	β	t	Sig.
Academic Anxiety	-0.28	0.09	-.25	-3.11	.002**
Learning Styles	0.31	0.10	.21	3.05	.003**
Home Environment	0.36	0.08	.32	4.50	.000**
AIDLE Engagement	0.42	0.09	.35	4.80	.000**
$R^2 = .61, \text{Adjusted } R^2 = .59, F(4,115) = 44.96, p < .001$					

* $p < .05$, ** $p < .01$

The regression model was found to be statistically significant, $F(4,115) = 44.96, p < .001$, explaining approximately 59% of the variance in academic achievement. Among the predictors, AIDLE engagement ($\beta = .35$) and home environment ($\beta = .32$) emerged as the strongest contributors, followed by learning styles ($\beta = .21$). Academic anxiety ($\beta = -.25$) had a significant negative effect. To visually summarize the regression outcomes, Table 4 presents the standardized coefficients (β values) of each predictor variable. These coefficients indicate that AIDLE engagement and home environment have the strongest positive effects on academic achievement, while academic anxiety exerts a negative impact

Table 4: Standardized Regression Coefficients for Predictors of Academic Achievement (N = 120)

Predictor Variables	β
Academic Anxiety	-0.25
Learning Styles	0.21
Home Environment	0.32
AIDLE Engagement	0.35

Note: All coefficients significant at $p < .05$. Higher β values indicate stronger predictive influence on academic achievement.

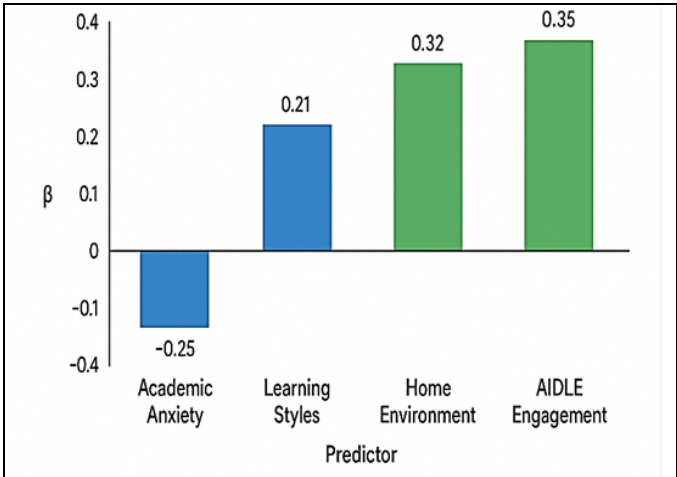


Fig 2: Standardized Regression Coefficients for Predictors of Academic Achievement

This figure illustrates the relative contribution (β values) of academic anxiety, learning styles, home environment, and AI-Integrated Digital Learning Engagement (AIDLE) in predicting students' academic achievement. Positive bars indicate facilitating effects, while the negative bar represents the inhibitory influence of academic anxiety. AIDLE engagement and home environment emerged as the strongest predictors of achievement. These findings indicate that students who engage actively in AI-enhanced learning and have supportive home environments tend to achieve higher academically, whereas elevated anxiety levels hinder performance.

Gender and School Type Differences

Independent samples t-tests were conducted to compare male and female students, as well as government and private school students, on the main study variables. No significant gender differences were found in academic achievement ($t = 1.23, p > .05$), though female students reported slightly lower anxiety and higher AIDLE engagement. Private school students

showed significantly higher scores in home environment and AI engagement ($p < .01$), suggesting better technological exposure and family support.

Discussion

The findings of the study are interpreted below in the light of existing theoretical and empirical evidence. The findings corroborate earlier studies (Halder & Mishra, 2014; Singh & Kumar, 2023; Chen *et al.*, 2024), affirming that academic achievement is a multidimensional construct influenced by psychological, cognitive, and environmental factors. The negative association between academic anxiety and achievement supports the Cognitive Interference Theory, which posits that heightened anxiety consumes attention resources essential for effective learning. The positive effects of learning styles and AI engagement demonstrate that when instructional strategies align with learners' preferences and are supported by intelligent technologies, students exhibit deeper engagement and improved outcomes. Similarly, a nurturing home environment

amplifies motivation, confidence, and persistence—key mediators of achievement.

These findings also align with the NEP 2020 framework, emphasizing integration of technology and socio-emotional support to cultivate adaptive and self-regulated learners. The predictive model underscores that optimal academic performance results from the synergistic interaction of low anxiety, effective learning preferences, technological engagement, and supportive home dynamics. The following section presents the conclusions, educational implications, and recommendations derived from the results.

Conclusion and Educational Implications

The present study explored the interrelationships among academic anxiety, learning styles, home environment, and AI-enhanced digital learning engagement (AIDLE) in shaping the academic achievement of senior secondary students in Rohtak, Haryana. The results revealed that while AI-integrated learning and a positive home environment significantly promote higher academic achievement, academic anxiety acts as a negative predictor. The analysis also demonstrated that AIDLE engagement and home environment jointly explain the largest proportion of variance in achievement, highlighting the importance of technological as well as psychosocial support systems in education.

These findings confirm that academic success in the digital age depends not only on cognitive ability but also on the synergistic balance between emotional stability, learner adaptability, and supportive home contexts. The results contribute to the growing understanding that AI-driven learning environments, when aligned with learners' cognitive styles and family support, can reduce anxiety and improve performance.

From an educational perspective, the study underscores the need for integrating AI tools and adaptive learning platforms into classroom practice, not as replacements for teachers but as augmentative supports for personalized instruction. Teachers should be trained to identify students' learning preferences and anxiety levels and adapt AI-assisted strategies accordingly. Parents, likewise, should cultivate emotionally supportive and structured home environments that encourage curiosity and digital literacy.

At the policy level, the findings align with the vision of the National Education Policy (NEP 2020), which advocates technology-enabled, learner-centric education that develops critical thinking, emotional well-being, and future-readiness. Institutions must therefore invest in AI-based infrastructure, teacher training, and parental awareness programs to ensure equitable access to digital learning opportunities.

Finally, the study opens avenues for future research exploring longitudinal effects of AI-based learning and interventions to manage academic anxiety. Further studies could also include larger, more diverse samples and examine additional variables such as self-efficacy, motivation, and digital literacy skills, thereby strengthening the evidence base for AI-driven educational innovation.

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