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ORIGINAL RESEARCH

When Technology Meets Anxiety: The Moderating Role of AI Usage in the Relationship Between Social Anxiety, Learning Adaptability, and Behavioral Problems Among Chinese Primary School Students

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Objective: This study aims to examine the relationships between social anxiety, learning adaptability, AI technology usage, and behavioral problems among primary school students, with a focus on the mediating role of learning adaptability and the moderating role of AI usage.

Methods: A cross-sectional survey was conducted among 1240 primary school students aged 8–15 in Luzhou, Sichuan Province. Social anxiety was measured using the Social Anxiety Scale for Children (SASC), learning adaptability was assessed with the Children's Learning Adaptability Questionnaire (CSAQ), behavioral problems were evaluated using the Child Behavior Checklist (CBCL), and AI tool usage was gauged through a self-developed questionnaire. Data analysis involved correlation and multiple regression analyses using SPSS, with the moderated mediation effect analyzed through Process Model 59.

Results: Social anxiety was found to significantly and positively predict behavioral problems, indicating that higher levels of social anxiety were associated with more behavioral problems. Learning adaptability partially mediated this relationship, suggesting that social anxiety not only directly impacts behavioral problems but also indirectly heightens the risk by reducing learning adaptability. Additionally, AI usage moderated the relationship between learning adaptability and behavioral problems, with a stronger effect of learning adaptability on behavioral problems observed at higher levels of AI usage. Specifically, the positive influence of learning adaptability on behavioral problems became more pronounced as AI usage increased, indicating that frequent AI use can amplify the impact of learning adaptability on behavioral outcomes.

Conclusion: Social anxiety increases the risk of behavioral problems in primary school students by diminishing learning adaptability. AI technology plays a moderating role in the relationship between learning adaptability and behavioral problems, with its effects becoming more pronounced at higher levels of AI usage. This highlights the need for educators to focus on improving students' learning adaptability, judiciously incorporate AI technology, and consider individual differences, particularly mental health, to foster comprehensive and healthy student development.

Keywords: social anxiety, learning adaptability, AI usage, behavioral problems, primary school students

Introduction

In recent years, the rapid proliferation of artificial intelligence (AI) technology in the field of education has significantly transformed traditional teaching models.[1] Tools such as intelligent tutoring software, automated grading systems, and data-driven personalized learning platforms not only improve students' learning efficiency and adaptability but also promote the development of personalized and autonomous education.[1] However, the widespread use of AI has also sparked profound reflections on the nature of knowledge, the purpose of education, and the relationship between humans

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and technology.[2] Although AI tools enhance the convenience of learning, they may also lead to students becoming overly dependent on technology, thereby weakening their autonomous learning and critical thinking abilities.[3] Furthermore, ethical issues such as data privacy, algorithm fairness, and decision transparency have become important challenges that need urgent solutions.[4] We must ensure that technological advancement does not exacerbate educational inequalities, while preserving the fundamental functions of education—character development and the process of socialization.

Meanwhile, the impact of AI technology on students' mental health and behavioral problems has also drawn the attention of educational psychologists. Personalized learning platforms can provide tailored learning programs based on students' needs, enhancing self-efficacy, motivation, and reducing learning stress.[5] However, excessive reliance on AI tools may lead to a deterioration of social skills, increased loneliness, and social anxiety.[6] Automated grading systems provide impersonal feedback that may fail to meet students' emotional needs, thereby affecting their mental health.[7] Furthermore, AI-driven monitoring and assessment of student behavior may increase stress and anxiety, even fostering dependence, which hinders the development of autonomy and creativity.[8] As technology increasingly permeates the learning process, exploring whether AI can alleviate or exacerbate students' behavioral problems has become an important issue for educators and researchers. The future transformation of education should leverage the advantages of AI while actively addressing its potential negative impacts to promote the comprehensive and healthy development of students.

Philosopher Martin Heidegger, in his philosophy of technology, argued that technology is not merely a tool used by humans to solve problems, but deeply influences our way of interacting with the world and redefines our understanding of self and our environment.[9] According to Heidegger, the widespread application of artificial intelligence (AI) technology in education not only changes the way students learn but also reshapes their cognitive patterns and behavioral habits.[10] AI tools, such as intelligent tutoring systems and personalized learning platforms, enhance learning efficiency and adaptability, but they may also subtly become new sources of stress.[11] For students who already experience anxiety in social interactions, the overuse or misuse of technology could increase psychological burdens and negatively impact their overall mental health.[12] Therefore, beyond focusing on the efficiency and effectiveness of AI in education, we must delve deeper into understanding its impact on student behavior and psychological adaptation, and critically reflect on the role and significance of technology in educational transformation.

On the other hand, we should emphasize the importance of individual subjective experiences in understanding educational phenomena. Each student's social anxiety is not merely an outward behavioral response but a profound internal emotional experience that directly impacts their performance and adaptability in the learning process.[13] For students with high levels of social anxiety, does the use of AI tools genuinely provide support, or does the complexity of technology-based learning and the increased cognitive load exacerbate their stress, weaken their adaptability, and lead to more behavioral issues? The core concern in education should be how the use of technology influences individual performance and adaptability through their subjective experiences.[12] This perspective reminds us that the application of technology in education should not only consider functionality and efficiency but also focus on students' subjective experiences and mental states, ensuring that technology truly contributes to their holistic development.

Behavioral Problems and Social Anxiety

Research on behavioral problems focuses not only on the decline in academic performance but also encompasses broader consequences for mental health and social behavior.[13] Students' behavioral issues can manifest as inattention in learning, aggressive behaviors, social withdrawal, and inappropriate conduct in the classroom, often accompanied by cognitive and emotional distress.[14] Prolonged behavioral problems may even lead to future antisocial behavior and psychological disorders.[15] Therefore, understanding the mechanisms behind behavioral problems and the associated risk factors is crucial for the healthy growth of students.

Philosopher Martin Heidegger, in his philosophy of technology, suggested that modern technology and social structures may contribute to a sense of alienation and isolation, leading to psychological anxiety and stress.[16] In educational settings, structured teaching methods and social interaction demands may exacerbate students' social anxiety, contributing to the emergence of behavioral issues.[17] Existentialist philosophy also emphasizes the tension between individual self-identity and societal expectations.[18] Social anxiety can be seen as a reflection of this tension, affecting students' behavior and the construction of their sense of self-worth.[17]

From a psychological perspective, there is a close relationship between behavioral problems and social anxiety. Social anxiety, as a common emotional disorder, especially among adolescents and young adults, significantly impacts their behavior and psychological adaptability. In social situations, anxiety can limit students' ability to participate in activities, leading to avoidance of class discussions or group projects, and may even result in inappropriate behaviors as a means of coping with inner tension and discomfort.[18] The study by Miers et al found that students with higher levels of social anxiety are more likely to exhibit avoidance behaviors in school settings, which not only affects their academic performance but also hinders the development of their social skills.[16]

Furthermore, prolonged social anxiety and behavioral problems may lead to more severe psychological disorders, such as depression and antisocial behavior.[13] Psychological research emphasizes that interventions such as cognitive behavioral therapy (CBT) can help students effectively manage social anxiety, thereby improving their behavior and overall mental health.[14] In educational practice, understanding and addressing the relationship between behavioral problems and social anxiety is essential for developing effective interventions and support strategies, aiming to promote students' holistic and healthy development.

Social Anxiety and Behavioral Problems

Social anxiety is a common emotional disorder, particularly prevalent among adolescents and young adults.[19] It affects not only individuals' everyday social interactions[20] but also has profound impacts on their academic performance and mental health.[21] Behavioral problems, which manifest as difficulties in adapting or inappropriate behavior in academic and social contexts, are intricately linked with social anxiety.[22]

From a philosophical perspective, the relationship between social anxiety and behavioral problems involves concepts of self-identity,[23] the meaning of existence,[24] and relationships with others and society.[25] Existentialist philosophers, such as Jean-Paul Sartre, argue that there is tension between an individual's self-identity and societal expectations.[24] Social anxiety can be viewed as a manifestation of this tension, where individuals experience internal conflict due to the fear of negative evaluation while striving for self-fulfillment, ultimately impacting their behavior.

Heidegger (Martin Heidegger) in his existential philosophy emphasized that the technologization and structuring of modern society may lead individuals to feel alienated and isolated.[26] In a highly structured educational environment, students face expectations from teachers and peers, which can easily trigger social anxiety.[19] This anxiety not only affects students' self-expression and social interactions but may also result in behavioral problems, such as inattention in class, aggressive behavior, or social withdrawal.[20] These behavioral issues reflect the coping mechanisms individuals employ in response to internal emotional distress and external social pressures, revealing the potential impact of a technologized educational environment on students' mental health.

From a psychological perspective, there is a significant relationship between social anxiety and behavioral problems. Social anxiety refers to excessive anxiety in social situations due to fear of negative evaluation or embarrassment, which can lead individuals to avoid social interactions and exhibit behaviors such as avoidance, silence, or self-isolation.[25] According to Social Cognitive Theory (Bandura, 1986), an individual's behavior is influenced by[27] their perception of external situations and their self-efficacy. For students with social anxiety, they tend to hold negative perceptions of social situations and have low self-efficacy, making them more likely to engage in avoidance behaviors when faced with social interactions.[25] Such avoidance not only limits their ability to participate in classroom activities and group collaborations but may also lead to poor academic performance.[20]

Research has shown that students with higher levels of social anxiety are more likely to exhibit avoidance behaviors, which negatively impact both their academic performance and their social skills development (Miers et al, 2011).[28] Prolonged social anxiety and behavioral issues can also lead to more serious psychological disorders, such as depression and antisocial behavior.[29] This negative cycle indicates that social anxiety is not only a major risk factor for behavioral issues but also may be worsened by the presence of these problems.[30]

Emotion regulation theory further explains how social anxiety can impact an individual's ability to regulate emotions, which subsequently affects their behavior.[31] Students with social anxiety often find it difficult to effectively regulate their emotions in social situations, which can lead to emotional outbursts or suppression.[32] This difficulty in emotion

regulation exacerbates anxiety and may also cause students to engage in inappropriate behaviors in social interactions, such as aggression or excessive withdrawal.[33]

Social anxiety causes students to fear participating in social activities, leading them to avoid classroom discussions, group collaborations, and other social situations.[19] This avoidance behavior not only impacts their academic performance but also limits the development of their social skills, further exacerbating their social anxiety.[34] Students with social anxiety often struggle to effectively regulate their emotions when faced with social situations, resulting in emotional outbursts or suppression.[35] These difficulties in emotion regulation can trigger aggressive behavior or excessive withdrawal, affecting their interactions with others.[36]

Students with social anxiety often lack confidence in their social abilities, resulting in low self-efficacy.[37] This low self-efficacy makes them more prone to negative perceptions when facing social challenges, which further affects their behavioral responses.[38] Such students tend to hold negative beliefs about social situations, thinking they will face negative evaluation or embarrassment.[39] These negative cognitions not only increase their anxiety but may also lead them to exhibit inappropriate behaviors in social contexts to alleviate their inner tension and discomfort.[40]

There is a complex and close relationship between social anxiety and behavioral problems, with both influencing each other and jointly affecting students' academic performance and mental health.[41] From a philosophical perspective, social structures and the technologized educational environment significantly impact individuals' self-identity and psychological state.[42] From a psychological standpoint, social anxiety affects self-efficacy,[43] emotional regulation ability,[44] and negative cognition,[45] which in turn lead to behavioral problems.[46] Understanding this relationship not only helps in designing effective educational interventions but also promotes students' comprehensive and healthy development. Future educational practice should integrate philosophical and psychological perspectives, focusing on students' subjective experiences and psychological well-being, providing comprehensive support to help them effectively manage social anxiety, improve behavioral issues, and move towards a healthier and more successful academic and social life.

The Mediating Role of Learning Adaptation

In today's highly competitive and technology-driven educational environment, students face increasing psychological pressure.[47] Social anxiety, as a common emotional disorder, significantly affects students' academic performance and mental health.[48] Meanwhile, behavioral problems have become a critical issue in the educational field that urgently needs to be addressed.[49] Recent research indicates that learning adaptation plays a crucial mediating role between social anxiety and behavioral problems.[50]

Learning adaptability is not just an individual's capacity to cope with external challenges but also a reflection of internal self-regulation and personal growth[51]. Existentialist philosophers like Jean-Paul Sartre emphasize the individual's freedom to choose and self-actualize in the face of life's adversities.[52] In this context, learning adaptability can be seen as a student's journey of self-reflection and autonomous regulation when faced with academic tasks and social pressures. This process leads to personal growth and transcendence.[51,53] Martin Heidegger's existential philosophy complements this view by suggesting that an individual's interaction with the environment shapes their existence and understanding of the world. Heidegger emphasizes that human beings are "thrown" into the world and must continuously navigate their existence within this framework.[54,55] Thus, learning adaptability is not merely a tool to overcome challenges, but a way for students to redefine themselves and their understanding of the world within the educational environment. Students with high learning adaptability are better equipped to integrate into learning environments and tackle social anxieties, thereby reducing behavioral issues.[51] Furthermore, Confucian philosophy's emphasis on balance and moderation resonates with this concept, viewing learning adaptability as the ability to strike a balance between academic and social pressures[56,57]. This balance not only alleviates social anxiety but also minimizes stress-induced behavioral problems, fostering holistic student development.

Learning adaptability refers to a student's capacity to effectively regulate their emotions and behaviors to meet the demands of different learning environments and challenges.[51] According to social cognitive theory (Bandura, 1986), an individual's behavior is influenced by both their perception of external circumstances and their sense of self-efficacy.[58] Students with higher learning adaptability often display stronger self-efficacy, enabling them to tackle learning challenges with confidence, which results in fewer behavioral problems.[51] These students tend to have better emotional regulation

skills, allowing them to manage negative emotions triggered by social anxiety more effectively.[59] This emotional stability helps them maintain balance when dealing with academic pressures and social challenges, reducing the likelihood of behavioral issues caused by emotional fluctuations[60,61]. Additionally, high adaptability often correlates with strong self-efficacy, meaning students believe in their ability to succeed in academic tasks.[62,63] This belief not only boosts their confidence in facing social anxieties but also reduces avoidance and aggressive behaviors that stem from a lack of confidence.[64–66] Furthermore, adaptable students are likely to engage in cognitive restructuring, where they view negative social situations as opportunities for growth rather than threats, which diminishes their anxiety and reduces behavioral problems[67,68]. Finally, students with high adaptability often seek social support, such as reaching out to teachers or peers for help.[69,70] This active pursuit of assistance alleviates social anxiety and fosters positive interactions, further minimizing the occurrence of behavioral issues[71–73].

Ringeisen and Ludwig (2014) found that social anxiety indirectly contributes to increased academic adaptation difficulties and behavioral problems by reducing students' confidence and engagement in the classroom.[74] This suggests that learning adaptability plays a key mediating role between social anxiety and behavioral issues. Specifically, social anxiety lowers students' adaptability to learning, which in turn increases the risk of behavioral problems. Additionally, other studies support this view. For example, Eysenck et al noted that learning adaptability can alleviate stress responses triggered by social anxiety, reducing the occurrence of maladaptive behaviors. By enhancing learning adaptability, educational interventions can effectively mitigate the negative impact of social anxiety on student behavior.[75]

The Moderating Role of AI Technology

The application of AI technology in education not only transforms teaching and learning processes but also profoundly impacts students' learning adaptability and behavioral issues. Martin Heidegger argued in his philosophy of technology that technology is not merely a tool but a force that shapes our way of being.[76] Following this perspective, AI technology not only optimizes learning processes but also reshapes students' cognitive patterns and behavioral habits. By providing personalized support and reducing learning burdens, AI tools can enhance students' adaptability, helping them better cope with academic challenges.[77] However, the double-edged nature of technology cannot be ignored. For students already experiencing emotional disorders like social anxiety, over-reliance on AI technology may increase cognitive load, adding to learning complexity and potentially triggering or worsening behavioral issues.[78] Moreover, existentialist philosophy emphasizes the tension between self-identity and free will in a highly technological society.[79] The extensive use of AI technology in education might lead to an over-reliance on technology, undermining students' autonomy and self-regulation.[80] This phenomenon affects learning adaptability and, through technological mediation, may exacerbate behavioral problems.[81,82] Therefore, from a philosophical viewpoint, the use of AI in education should strike a balance between convenience and potential psychological burdens, ensuring that technological progress does not come at the cost of students' mental health and autonomy.

The use of AI technology in education should have a significant moderating effect on the relationship between learning adaptability and behavioral issues. According to Social Cognitive Theory (Bandura, 1986), an individual's behavior is influenced by their perception of external circumstances and their sense of self-efficacy.[83,84] The Technology Acceptance Model further indicates that individuals' perceptions of the usefulness and ease of use of technology affect their acceptance and effectiveness in using it.[85,86] In educational settings, AI tools can enhance students' learning adaptability by providing personalized support and reducing learning burdens.[81,82] However, research shows that over-reliance on AI technology may increase cognitive load, especially for students with poor learning adaptability, making learning more complex and exacerbating behavioral issues.[87] AI tools can automate grading, provide instant feedback, and help students complete learning tasks more efficiently, thereby improving learning adaptability and reducing behavioral problems caused by academic stress.[88] AI platforms can provide customized learning resources and guidance based on students' progress and understanding, enhancing their self-efficacy, reducing social anxiety, and minimizing behavioral issues.[89] For students with low learning adaptability, the complexity and difficulty of AI tools may increase cognitive load, leading to frustration and anxiety, thereby exacerbating behavioral problems. Over-reliance on AI technology can weaken students' independent learning and problem-solving abilities, affecting their self-regulation and emotional management, which in turn may lead to more behavioral problems.[88,89]

Ringeisen pointed out that social anxiety indirectly affects behavioral issues by reducing students' learning adaptability.[90] The usage of AI technology may further modulate this relationship by enhancing or diminishing learning adaptability. For instance, moderate use of AI technology can enhance adaptability, mitigating the negative impact of social anxiety on behavioral issues, whereas over-reliance may increase the risk of behavioral problems.[91] Thus, understanding the moderating role of AI in this process is crucial for designing effective educational interventions.[88,92]

The application of AI technology in education has a complex, multi-layered moderating effect on the relationship between learning adaptability and behavioral issues. Through the lens of the Technology Acceptance Model and Social Cognitive Theory, we learn that while AI tools can enhance learning adaptability, they may also exacerbate behavioral problems by increasing cognitive load and fostering dependency on technology. This is especially true for students with pre-existing social anxiety, where the use of AI requires more caution and personalization to avoid potential negative effects. From a philosophical and psychological perspective, it is important not only to focus on the functionality and efficiency of technology but also to deeply understand its impact on students' self-identity, emotional regulation, and behavior. Future educational transformations should integrate multidisciplinary theories and research to create comprehensive intervention strategies, ensuring that AI technology genuinely promotes students' learning adaptability and mental health, reduces behavioral problems, and fosters holistic development.

Hypothesis Development

Based on the analysis above and the discussion surrounding the relationships between social anxiety, learning adaptability, AI technology usage, and behavioral issues (as shown in Figure 1), the following hypotheses are proposed:

Hypothesis 1: The Direct Impact of Social Anxiety on Behavioral Issues

H1: Social anxiety significantly and positively predicts students' behavioral problems.

According to Social Cognitive Theory, social anxiety may cause students to exhibit inappropriate behaviors in learning environments, such as avoidance, excessive anxiety, and difficulties in social interactions. Thus, the higher the social anxiety, the greater the likelihood of behavioral problems among students.

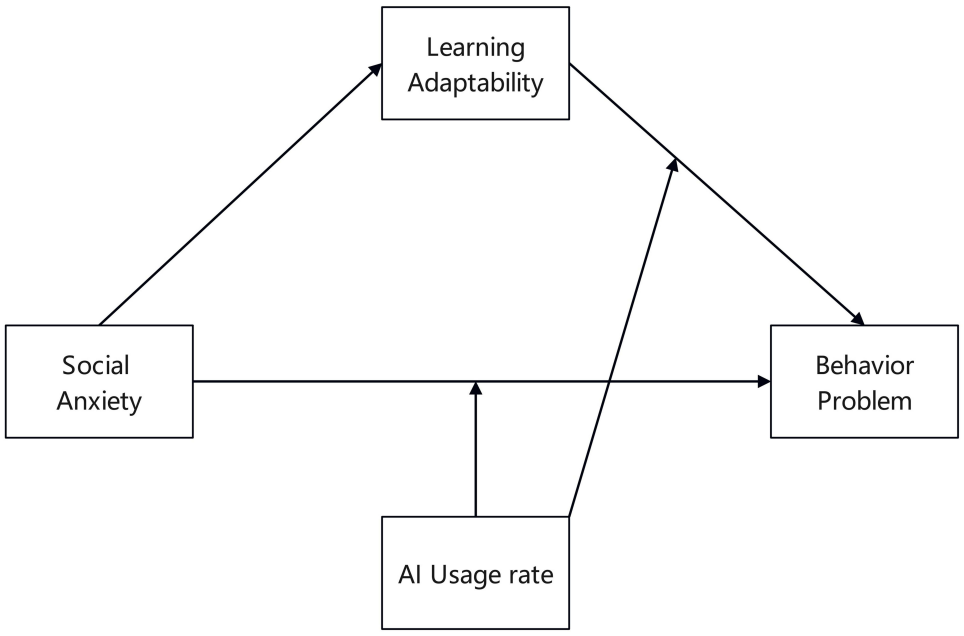

Figure 1 Hypothetical Model.

Hypothesis 2: The Mediating Role of Learning Adaptability Between Social Anxiety and Behavioral Issues

H2: Learning adaptability mediates the relationship between social anxiety and behavioral problems.

Research indicates that social anxiety not only directly influences behavioral problems but may also indirectly lead to such issues through its negative impact on learning adaptability. In other words, students with high social anxiety and poor learning adaptability are more likely to exhibit behavioral problems.

Hypothesis 3: The Moderating Role of AI Usage in the Relationship Between Learning Adaptability and Behavioral Issues

H3: AI usage moderates the effect of learning adaptability on behavioral issues.

The use of AI technology may impact students' learning adaptability differently depending on individual differences. For students with good learning adaptability, AI tools may reduce behavioral problems. However, for those with poor adaptability, frequent AI use might increase behavioral issues. Therefore, the effect of learning adaptability on behavioral problems may be more pronounced among students with higher AI usage.

Hypothesis 4: The Moderating Role of AI Usage in the Direct Relationship Between Social Anxiety and Behavioral Issues

H4: AI usage moderates the direct impact of social anxiety on behavioral issues.

AI tools could either increase the cognitive load or provide technological support, influencing how social anxiety impacts behavioral problems. Among students with high AI usage, social anxiety may lead to more severe behavioral issues due to additional cognitive demands. However, if AI tools effectively reduce learning burdens, they may mitigate the effect of social anxiety on behavioral problems.

Methods

This study employed a cross-sectional survey design, collecting data via questionnaires. Data cleaning, standardization, correlation analysis, and multiple regression analysis were performed using SPSS. To examine the moderated mediation effects, the Process plugin (Model 59) was used, with social anxiety as the independent variable, learning adaptability as the mediating variable, behavioral issues as the dependent variable, and AI usage rate as the moderating variable. The analysis was conducted with a 5000-sample bootstrap.

The sample consisted of 1369 children from general elementary schools in Luzhou, Sichuan Province, China, using a combination of online and offline data collection under parental supervision. A total of 1240 valid responses were obtained, from children aged 8–15 (619 males and 750 females). Parents or guardians provided informed consent for their children's participation in the study.

Social anxiety was assessed using the Social Anxiety Scale for Children (SASC), an 18-item scale with responses ranging from 1 (never) to 5 (always), measuring the level of social anxiety in children. The SASC has been validated across multiple cultural contexts, demonstrating high internal consistency (Cronbach's α typically ranging from 0.80 to 0.90) and strong discriminant validity in groups with social anxiety.[93]

The Children's Study Adaptability Questionnaire (CSAQ) was used to assess physical and psychological factors potentially leading to learning difficulties. Parents or teachers familiar with the child completed the 80-item questionnaire, which is divided into eight subscales, each with 10 items. The responses range from "never", "sometimes", to "often". A higher score indicates a higher likelihood of abnormal adaptability.[94]

Behavioral problems were measured using the Child Behavior Checklist (CBCL), specifically the behavior problems subscale. The CBCL is widely used for assessing behaviors in children and adolescents. It rates the frequency of specific behaviors, with higher scores indicating more severe behavioral issues. CBCL has demonstrated reliability and validity across various cultural and linguistic contexts, with internal consistency typically ranging from 0.78 to 0.94.[95]

AI tool usage was evaluated using a self-designed questionnaire containing five frequency-related items, with responses ranging from 1 (never) to 5 (often). Although self-constructed, the questionnaire was developed following established literature and standards to ensure content and construct validity. Higher scores reflect more frequent AI usage.

All participant information was kept strictly confidential and used solely for statistical analysis in this research. Participants were free to withdraw from the study at any time without any consequences.

Results

Descriptive Statistics

The mean AI usage rate among students was 1.3901 (as shown in Table 1), indicating that the frequency of AI tool use in daily life is generally low, with most students opting to use AI tools infrequently or not at all. The standard deviation was 1.03862, showing a wide variation in AI usage levels. The mean score for behavioral problems was 8.4974, suggesting that most students had low levels of behavioral issues. However, the standard deviation of 6.44286 indicates significant variability in behavioral problem scores among students.

The mean score for social anxiety was 4.7779 (see Table 1), reflecting that the majority of students had low to moderate levels of social anxiety. The standard deviation was 3.80140, showing substantial differences in social anxiety levels. The mean score for learning adaptability was 4.5000, indicating that students generally had low to moderate levels of learning adaptability. The standard deviation of 2.85913 suggests that the variation in learning adaptability among students was not particularly large.

The data (as indicated in Table 1) reveal significant individual differences in both behavioral problems and social anxiety. Furthermore, the skewness and kurtosis values for behavioral problems suggest that a small number of students exhibited highly pronounced behavioral issues. In contrast, the skewness and kurtosis for gender and AI usage were relatively flat, indicating a more dispersed distribution of these variables. The mean AI usage rate among students was 1.3901, indicating that the frequency of AI tool use in daily life is generally low, with most students opting to use AI tools infrequently or not at all. The standard deviation was 1.03862, showing a wide variation in AI usage levels. The mean score for behavioral problems was 8.4974, suggesting that most students had low levels of behavioral issues. However, the standard deviation of 6.44286 indicates significant variability in behavioral problem scores among students.

Correlation

The correlation coefficient between gender and behavioral issues is $r = 0.131$ ($p < 0.01$), indicating a significant positive correlation, suggesting that gender may have some influence on behavioral issues (as shown in Figure 2). The correlation between gender and social anxiety is $r = -0.070$ ($p < 0.05$), indicating a significant negative correlation between the two variables.

The correlation between behavioral issues and social anxiety is $r = 0.501$ ($p < 0.01$), showing a significant positive relationship, meaning individuals with more behavioral problems tend to experience more severe social anxiety. The correlation between behavioral issues and learning adaptability is $r = 0.191$ ($p < 0.01$), indicating a significant positive correlation, suggesting that as behavioral problems increase, so does learning adaptability (Figure 2).

Table 1 Descriptive Statistics

Variable	Min	Max	Mean	SE	SD	Variance	Skewness	Kurtosis
AI Usage Rate	0.00	5.00	1.39	0.03	1.04	1.08	−0.26	−1.19
Behavioral Issues	0.00	62.00	8.50	0.17	6.44	41.51	1.26	4.05
Social Anxiety	0.00	20.00	4.78	0.11	3.80	14.45	0.49	−0.37
Learning Adaptability	0.00	17.00	4.50	0.08	2.86	8.18	0.48	0.04

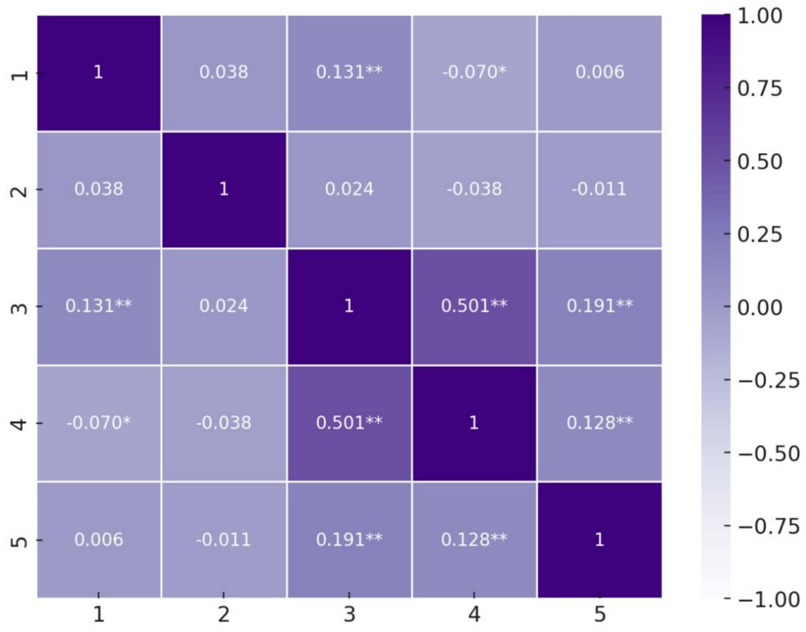

Figure 2 Correlation Heatmap. 1 = Gender; 2 = AI Usage Rate; 3 = Behavioral Issues; 4 = Social Anxiety; 5 = Learning Adaptability. *Correlation is significant at the 0.05 level (two-tailed); **Correlation is significant at the 0.01 level (two-tailed).

Lastly, the correlation between social anxiety and learning adaptability is $r = 0.128$ ($p < 0.01$), indicating a significant positive correlation between these two variables, as depicted in Figure 2.

Collinearity Diagnostics

The eigenvalues range from 1.137 to 0.869 (Table 2), indicating that each dimension contributes relatively evenly to the variance, with no significant bias. The condition indices range from 1.000 to 1.144, well below the threshold of 30, suggesting no serious multicollinearity issues.

In Dimension 1, social anxiety and learning adaptability contribute more to the variance. In Dimension 2, the constant and AI usage rate show notable contributions. In Dimension 3, AI usage rate explains a higher proportion of variance, while in Dimension 4, social anxiety and learning adaptability reveal a moderate correlation.

Overall, the analysis of eigenvalues, condition indices, and variance proportions (Table 2) indicates no significant multicollinearity among the independent variables, and the regression analysis results are stable and reliable.

Table 2 Collinearity Diagnostics

Dimension	Eigenvalue	Condition Index	Constant	AI Usage Rate	Social Anxiety	Learning Adaptability
1	1.14	1.00	0.00	0.05	0.42	0.39
2	1.02	1.06	0.57	0.38	0.00	0.03
3	0.98	1.08	0.43	0.54	0.00	0.04
4	0.87	1.14	0.00	0.03	0.57	0.53

Note: Dependent Variable: Behavioral Issues.

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Regression Analysis

As presented in Table 3, the constant has a coefficient of B = 0.009, $t = 0.373$, and $p = 0.709$, indicating that the constant is not significant and has no meaningful impact on the results. For AI usage rate, B = 0.044, with a standardized coefficient Beta = 0.043, $t = 1.785$, and $p = 0.075$, which is close to significance but not quite there. The 95% confidence interval ranges from −0.004 to 0.092, including 0, further confirming its lack of significance. The zero-order correlation between AI usage rate and behavioral problems is 0.023, with a partial correlation of 0.051 and part correlation of 0.043. The collinearity statistics show a tolerance of 0.999 and a VIF of 1.001, indicating no multicollinearity issue with AI usage rate.

As demonstrated in Table 3, for social anxiety, B = 0.490, with a standardized coefficient Beta = 0.486, $t = 19.847$, and $p < 0.001$, indicating a significant and strong positive predictive effect on behavioral problems. The 95% confidence interval ranges from 0.441 to 0.538, indicating precise estimation. The zero-order correlation between social anxiety and behavioral problems is 0.501, with a partial correlation of 0.491 and part correlation of 0.481, showing a strong and significant impact. Collinearity statistics show a tolerance of 0.982 and VIF of 1.018 (Table 3), indicating very low risk of multicollinearity, meaning social anxiety's effect is independent of other variables.

For learning adaptability, B = 0.134, with a standardized coefficient Beta = 0.132, $t = 5.391$, and $p < 0.001$, indicating a significant positive effect on behavioral problems, though weaker than social anxiety (Table 3). The 95% confidence interval ranges from 0.085 to 0.183, showing a small and stable interval. The zero-order correlation between learning adaptability and behavioral problems is 0.194, with a partial correlation of 0.151 and part correlation of 0.131, showing a weaker but still significant effect. The collinearity statistics show a tolerance of 0.984 and a VIF of 1.017, indicating no multicollinearity issue between learning adaptability and other variables.

Social anxiety is the strongest predictor, with a significant and large positive impact on behavioral problems. Learning adaptability also significantly influences behavioral problems but to a lesser extent. AI usage rate does not significantly predict behavioral problems, and although its coefficient is positive, its explanatory power is low. All variables have tolerance values near 1 and low VIF values (Table 3), indicating no serious multicollinearity issues.

Model Validation

When learning adaptability is the dependent variable, the overall model is significant and explains 17.4% of the variance ($R^2 = 0.174$, $p = 0.0001$). Social anxiety has a significant positive effect on learning adaptability (B = 0.1248, $p < 0.001$), indicating that higher social anxiety is associated with stronger learning adaptability. AI usage rate and its interaction term do not significantly affect learning adaptability ($p > 0.05$), suggesting that AI usage does not significantly moderate the relationship between social anxiety and learning adaptability (Figure 3).

When behavioral issues are the dependent variable, the model explains 27.57% of the variance ($R^2 = 0.2757$, $p < 0.0001$), and the overall model is significant. Social anxiety has a direct significant positive effect on behavioral problems (B = 0.4949, $p < 0.001$), indicating that higher social anxiety leads to more behavioral issues (Figure 3). Learning adaptability also has a significant positive effect on behavioral problems (B = 0.1344, $p < 0.001$), showing that stronger learning adaptability can increase behavioral issues (Figure 3). The interaction between learning adaptability and AI usage rate significantly affects behavioral problems (B = 0.0624, $p = 0.0107$), suggesting that AI usage moderates the

Table 3 Multiple Regression

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	95.0% CI	Correlations	Collinearity Statistics
	B	Std. Error	Beta		Lower Bound	Upper Bound	Zero-order
1 (Constant)	0.01	0.02		0.37	0.71	−0.04	0.06
AI Usage Rate	0.04	0.02	0.04	1.79	0.08	−0.01	0.09
Social Anxiety	0.49	0.02	0.49	19.85	0.00	0.44	0.54
Learning Adaptability	0.13	0.02	0.13	5.39	0.00	0.09	0.18

Note: Dependent Variable: Behavioral Issues.

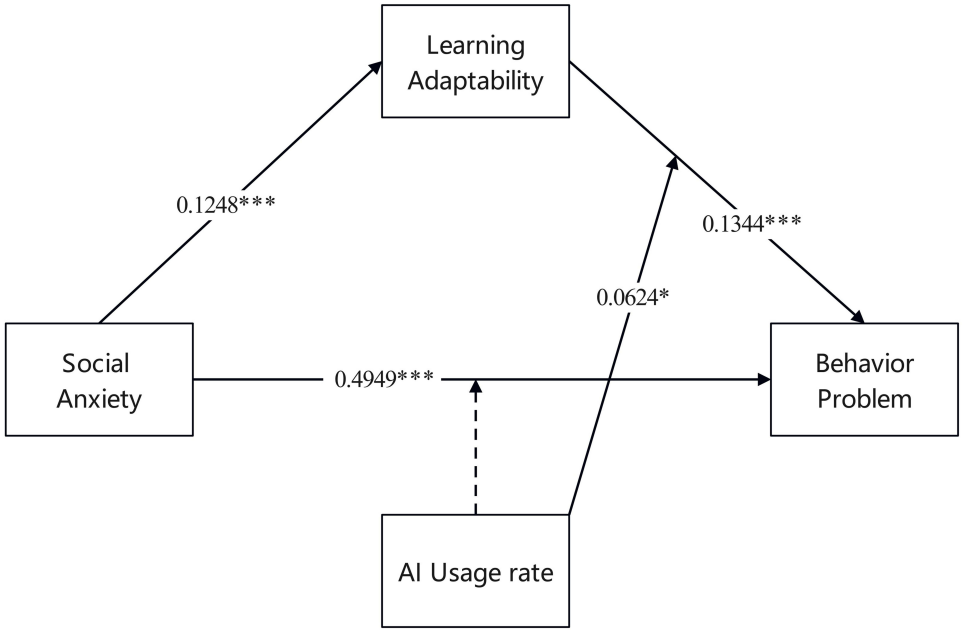

Figure 3 Model Validation. The solid lines represent significant effects, while dashed lines indicate non-significant effects. * denotes a p-value < 0.05; *** denotes a p-value < 0.001.

relationship between learning adaptability and behavioral problems (Figure 3). Specifically, at higher levels of AI usage, the effect of learning adaptability on behavioral issues becomes stronger (Figure 4).

As shown in Figure 3, the direct effect of social anxiety on behavioral problems is significant across different levels of AI usage, indicating that regardless of AI usage rate, social anxiety consistently has a significant positive effect on behavioral problems. Regarding indirect effects, the mediating role of learning adaptability between social anxiety and behavioral problems varies depending on the level of AI usage. As AI usage increases, the indirect effect strengthens, indicating that at higher AI usage levels, the impact of social anxiety on behavioral problems through learning adaptability becomes more pronounced (Figure 4).

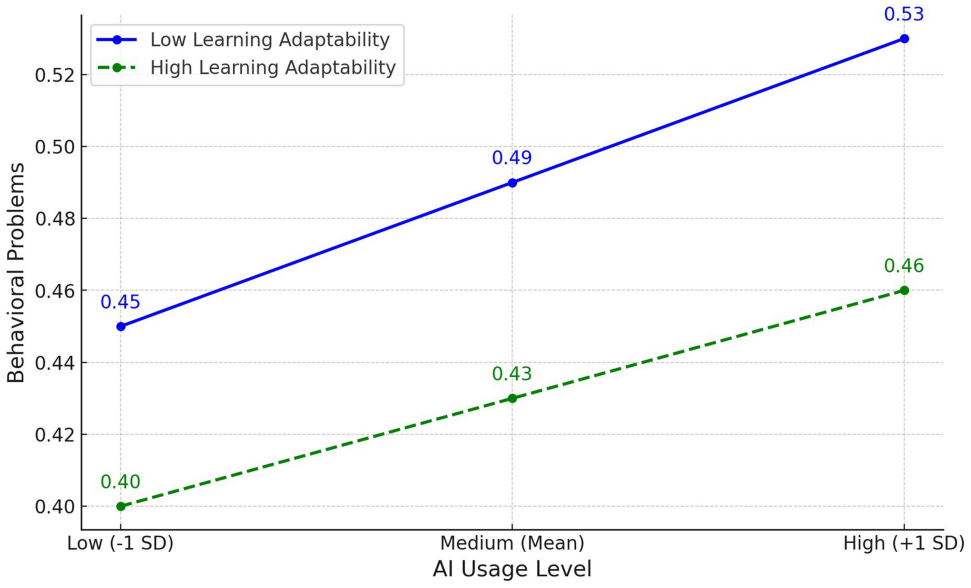

Figure 4 Moderation Effect.

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As illustrated in Figure 1, high learning adaptability serves as a protective factor against behavioral problems associated with increased AI usage. Individuals with high adaptability show fewer behavioral issues as AI usage rises, while those with low adaptability experience more behavioral problems with higher AI usage. This suggests that providing adaptability training or support for those with lower adaptability may mitigate the negative impacts of high AI usage.

Discussion

This study aimed to explore the relationships between social anxiety, learning adaptability, AI usage rate, and behavioral problems among students. Through a survey of 1240 primary school students aged 8–15, the findings revealed that social anxiety significantly predicts behavioral problems (supporting H1). In other words, the higher the level of social anxiety, the more behavioral issues students tend to have (Figure 3).

Additionally, learning adaptability was found to partially mediate the relationship between social anxiety and behavioral problems (supporting H2), indicating that social anxiety not only directly influences behavioral problems but also indirectly increases the risk of these problems by reducing learning adaptability (Figure 3).

Furthermore, AI usage rate moderates the relationship between learning adaptability and behavioral problems (supporting H3). Specifically, for students with higher AI usage rates, the impact of learning adaptability on behavioral problems is more pronounced (Figure 4).

However, AI usage rate did not significantly moderate the direct relationship between social anxiety and behavioral problems (failing to support H4) (Figure 3). Although AI usage did moderate the relationship between learning adaptability and behavioral problems, making the influence of learning adaptability more significant in students with higher AI usage, it did not affect the direct impact of social anxiety on behavioral problems.

Consistent with previous research, our study found a significant positive correlation between social anxiety and behavioral problems. Social anxiety can lead students to either avoid or display inappropriate behaviors in social situations, which increases the likelihood of behavioral issues.[96,97] Other studies have also indicated that learning adaptability plays a mediating role between emotional factors and behavioral problems.[98–100] Our research further confirms this, highlighting the importance of learning adaptability.

Previous studies have rarely examined the moderating role of AI technology in the relationships discussed. This study found that AI usage significantly moderated the impact of learning adaptability on behavioral problems (H3 supported), but did not moderate the direct effect of social anxiety on behavioral problems (H4 not supported). This may be because the use of AI technology primarily influences students' learning processes (ie, learning adaptability) rather than directly affecting their emotional states (eg, social anxiety).

Some studies suggest that technology can help alleviate anxiety,[101] but this study did not find that AI usage moderates the impact of social anxiety on behavioral problems. This may be because students with high levels of social anxiety do not experience effective relief when using AI technology, and the complexity of the technology might even increase their cognitive load, exacerbating their anxiety.

Heidegger's philosophy of technology posits that technology is not merely a tool but a force that profoundly shapes human existence, influencing how individuals perceive and interact with the world.[102,103] In the context of education, this view suggests that AI technology, while beneficial in enhancing learning adaptability, can also impose constraints on students' autonomy if relied upon too heavily. Our study's findings align with this view, showing that AI usage significantly impacts learning adaptability, but it does not directly moderate the emotional factors, such as social anxiety, that influence behavior. This limitation highlights the need for a balanced approach in integrating AI into educational practices—one that promotes learning while also acknowledging and addressing students' emotional needs.

Building on Heidegger's critique of technology's potential to alienate individuals from their authentic selves, we suggest that AI tools, while enhancing learning adaptability, may inadvertently overshadow the importance of fostering emotional self-awareness. Our study emphasizes that social anxiety, as a subjective emotional experience, directly impacts students' behavioral outcomes. This finding aligns with existentialist philosophy, which stresses the importance of individual subjective experience and self-realization in shaping behavior.[104] In light of these insights, educators must not only focus on technological solutions but also ensure that students' emotional needs are considered and supported.

This approach resonates with the philosophical tradition of prioritizing human agency and emotional authenticity in educational settings.

To further expand upon this, previous research in technology and education has explored how AI can provide personalized learning experiences, yet few studies have adequately addressed the limitations of AI in emotional regulation. By exploring these dynamics in future research, we can better understand the nuances of how AI and emotional factors interact in educational contexts.

As AI usage did not moderate the impact of social anxiety on behavioral problems, this indicates that technological interventions may have limited effectiveness in addressing emotional issues. For students with high social anxiety, psychological counseling and emotional management training may be more effective. This study found that learning adaptability mediates the relationship between social anxiety and behavioral problems, and this mediation is moderated by AI usage. This suggests that enhancing students' learning adaptability, combined with appropriate AI application, can help reduce behavioral problems.

While advancing the application of AI technology, we must also focus on students' emotional and psychological well-being, ensuring that technology does not become a new source of stress. AI should support personalized education but must account for individual differences, especially in emotional and psychological states.

In addition to the findings on social anxiety, learning adaptability, and AI usage, it is important to consider the broader educational outcomes influenced by AI technology. While our study focused on the impact of AI on mental health, AI has the potential to shape a wide range of educational outcomes, including critical thinking, creativity, and overall cognitive development. For instance, AI tools can provide personalized learning experiences that encourage students to explore complex problems, fostering creativity and critical thinking. These tools can engage students in higher-order thinking by adapting to their individual learning styles and offering challenges suited to their cognitive abilities. However, it is essential that AI applications are designed to strike a balance between cognitive stimulation and emotional support, especially for students experiencing social anxiety.

To make AI more effective in fostering critical thinking and creativity, AI tools could be integrated with strategies that promote emotional regulation and resilience. For example, AI systems could include features that recognize when students may be feeling frustrated or anxious and adjust the complexity of tasks or offer encouragement, reducing the cognitive load and helping to build emotional resilience. Real-world examples, such as AI-powered platforms that adapt to the student's emotional state and learning pace (eg, chatbots or intelligent tutoring systems), have shown promise in enhancing both cognitive and emotional development. These AI tools, when carefully implemented, can be powerful in promoting students' well-being and overall academic performance.

Additionally, incorporating empirical data from longitudinal studies and teacher feedback would further strengthen the practical relevance of the study. Practical interventions, such as teacher training programs on how to integrate AI tools while maintaining emotional sensitivity, could be effective in improving students' learning adaptability and mental health outcomes. For example, training educators to recognize signs of social anxiety in students and use AI in a way that enhances rather than detracts from their emotional well-being would be a valuable step forward in the application of AI in education.

This study used a cross-sectional design, which cannot determine causal relationships between variables. Future research should employ a longitudinal design to track changes in these variables over time and explore the long-term effects of AI usage on students' psychological outcomes. Moreover, the data were primarily collected from self-report questionnaires, which may introduce social desirability bias and subjective errors. To improve the reliability of the findings, future studies should integrate teacher evaluations and objective measurement tools. Additionally, the study sample was limited to a single region, which may affect the generalizability of the results. Students from different regions and cultural backgrounds may have distinct technology usage habits and psychological characteristics. Future research should aim to include more diverse samples to capture these variations. Furthermore, it would be valuable to explore a broader range of AI applications, including personalized learning systems and AI-based mental health interventions, to better understand their diverse impacts on students' mental health and behavior.

In future research, we plan to adopt a more diverse data collection approach, incorporating interviews and observations to obtain more comprehensive data and verify the reliability of the findings. This will allow us to capture a wider

range of perspectives on the impact of AI usage, including the qualitative aspects of students' experiences that may not be fully captured through self-report surveys alone. Further, we can differentiate between various types of AI tools, such as intelligent tutoring software and automated grading systems, to explore their distinct impacts on students' psychology and behavior. By examining how different AI tools are used in educational settings, we can gain deeper insights into which aspects of AI technology are most beneficial or challenging for students with varying emotional and psychological needs. Lastly, we may explore how to integrate psychological intervention strategies into AI technologies to enhance their effectiveness in emotional management. For example, AI systems could incorporate features to detect signs of stress or anxiety and adapt their interactions accordingly, offering personalized emotional support. By combining AI's educational benefits with psychological insights, we could create a more holistic approach to supporting students' academic and emotional development.

Conclusion

This study reveals the complex relationships between social anxiety, learning adaptability, AI usage, and students' behavioral problems. The findings show that social anxiety not only directly increases the risk of behavioral problems but also indirectly influences them by reducing learning adaptability. AI usage moderated the relationship between learning adaptability and behavioral problems, but it did not moderate the direct impact of social anxiety on behavioral problems. These findings have important implications for educational practice, suggesting that educators need to consider individual differences, especially in mental health, when incorporating AI technology.

While AI can enhance learning adaptability, its direct role in addressing emotional challenges like social anxiety remains limited. However, the study suggests that certain types of AI tools, particularly those designed for emotional support (eg, AI-driven counseling tools), might provide more direct benefits for students' emotional regulation. Future research should explore these specific AI applications and their potential to support students' emotional and psychological needs.

Moreover, psychological counseling may remain more effective for students with high social anxiety. Still, AI could play a complementary role by indirectly supporting emotional management through improvements in learning adaptability. As AI technology continues to evolve, it is essential to investigate how these tools can be integrated with traditional psychological interventions to enhance students' emotional and academic well-being.

Finally, the limitations of our study, particularly the cross-sectional design and reliance on self-report data, should be considered when interpreting the findings. Future research would benefit from longitudinal studies and the integration of objective measurement tools, such as teacher evaluations, to provide more robust insights into the causal relationships between these variables.

Data Sharing Statement

The data that support the findings of this study are available from the authors.

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Ethical Statement

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The study has been reviewed by the Ethics Review Committee of Southwest Medical University. All participants provided informed consent before participation. Participants' privacy and confidentiality were safeguarded throughout the research process, and all data were collected and analyzed in compliance with ethical standards.

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