# The Relationship Between College Students' Creativity and Academic Achievement Under the Background of Sustainable Development - Using Deep Learning as a Mediating Variable

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**Abstract:** *College students in applied undergraduate colleges pay more attention to the learning of practical skills. In order to reflect the effect of students' skill learning, academic performance is the best indicator. The academic achievement of college students not only has a significant impact on their personal development, but also has an important relationship with the education of colleges and universities and the harmony and stability of society. Based on the purpose of education deepening and the sustainable development of talent training, this paper takes college students from applied undergraduate colleges as the research object, and uses data mining technology to mine the factors that affect college students' academic achievement (AA). The research shows that the factors that affect the AA of college students include gender, origin, in-depth learning method, creativity and others, and then through the significance analysis obtains the degree of influence of these factors on the AA of college students, and the obvious interaction between the variables.*

**Keywords:** *academic achievement, applied undergraduate universities, creativity, deep learning, sustainable development*

## 1. Introduction

The sustainable development of college students (CS) is a big problem that colleges and universities are facing. Colleges and universities (CAU) should cultivate students' all-round development if they want to inject constructive power into the society. This paper analyzes the relationship among creativity, learning achievement and deep learning mode, and puts forward sustainable development suggestions based on this, providing reference for talent cultivation in (CAU).

At present, many scholars have conducted in-depth research on the relationship between CS' creativity and academic achievement in the context of sustainable development - with deep learning as an intermediary variable. Some scholars have found through research that to obtain the breadth of information requires the active participation of learners, who collect information through multiple channels such as reading, listening, watching, speaking, and doing, and then differentiating and integrating to internalize and create new things (Sorour, Khairy & Elkholy, 2021). Deep learning emphasizes the integration and construction of knowledge. Today, in the era of the vigorous development of the Internet, CS can not only obtain physical learning resources, such as books, but also electronic learning resources. CS will integrate learning resources to show that students are exploring deep learning methods. They should also be able to integrate old and new knowledge, so as to deepen their understanding of new knowledge, which is conducive to long-term preservation and flexible application in the future (Galán-Casado *et al*., 2020; Al-Madani, 2020). A scholar takes students as the research object, investigates the factors that affect the academic performance of students, and concludes that gender differences, learning styles, personality, learning motivation and other demographic characteristics will have a significant impact on performance (Tekin & Mustu, 2021).

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Although there are many related researches on this, in order fundamentally to improve the level of CS in all aspects, it is necessary to realize the balanced development of students.

This paper introduces the relevant theories of deep learning, creativity and learning achievement, and analyzes the relationship between the three, and then puts forward six hypotheses that will be investigated in this paper. This involves analyzing whether there is a relationship between them and, if so, what kind of relationship exists. The experimental results indicate that the hypotheses proposed in this paper are supported.

## 2. Relevant Theoretical Analysis

### 2.1. Deep Learning, Creativity and Learning Achievement

#### 2.1.1. Deep Learning

Deep learning emphasizes the transfer and application of knowledge, requiring learners to connect new knowledge with existing experience and solve problems through practice and application, so as to better transfer and apply knowledge (Motahari, Rahimibashar & Ghasemnegad, 2020); deep learning emphasizes self- reflection, deep learners need to re-understand their own learning through reflection, reflect on their own confusion and problems in learning, adjust their mentality and learning plan, and propose improvement measures (Djudin, 2018); deep learning emphasizes the development of critical thinking ability, which is similar to shallow learning. In contrast, deep learning emphasizes the deep processing of knowledge, that is, the four cognitive levels of application, analysis, evaluation, and creation (Salari *et al*., 2018).

#### 2.1.2. Creativity

The criterion for creative thinking (CT) is the most common measure of creativity. Frequently, these types of measurements are classified as different thought tests. A large number of questions are asked to test creative knowledge and thinking process, and the level of creativity can be judged by testing the fluency and flexibility of thinking (Gebauer *et al*., 2019). There are also some basic materials that require subjects to use CT to solve problems as innovatively as possible, and the solutions are usually not unique (Prifti & Rapti, 2018).

Some researchers and colleagues developed a set of test questions, the SOI Creativity Test, which consists of 14 parts. Among them, the first 10 language comprehension tests and the last four are non-verbal tests in graphic form (Nakano, Ribeiro & Virgolim, 2021).

#### 2.1.3. Academic Achievement

Academics have differing views on the definition of academic achievement. Some scholars believe that academic achievement can reflect students' performance level through examinations, assessments and papers, and some scholars believe that AA is measured by the knowledge and skills acquired by students in the learning stage (Bultseva & Lebedeva, 2021).

#### 2.1.4. The Relationship between CS' Creativity, AA and Deep Learning Style

Relatively many studies have explored the relationship between creativity and AA, and research has shown that creativity is associated with some positive outcomes. Aguilar's (2018) research found that students' creativity level can predict their achievement level. Kalantari and Toosi (2018) demonstrated that there is sufficient empirical evidence to support the relationship between creativity, AA and deep learning (DL) style, and has consistent associations among CS of various grades and academic levels. On the contrary,

lack of creativity will bring serious consequences to students, including poor academic performance, increased possibility of not participating in club activities and other activities which are important indicators of students' AA (Suprapto *et al*., 2018). In the study of the influencing factors of college students' creativity, a large number of studies have shown that students' personality characteristics, growth environment and family education, curiosity are all influencing factors, but not only is DL one of the factors that plays a crucial role, DL is in fact the source of creativity.

At the same time, DL as a behaviour or tendency plays a mediating role as a bridge and link among many factors that affect AA. Haji, Zareh and Dadashi's (2019) research explores the relationship between high school students' daily academic flexibility level and their academic performance, and the mediating role (MR) of DL methods. The MR of DL methods is mainly reflected in reflective of the MR of learning and cooperative learning (Haji *et al.*, 2019).

### 2.2. Significance Test Model

Significance tests are used to test whether the difference between two populations is significant. The t-test statistic is:

$$t = \frac{\overline{X} - \mu}{\frac{\sigma_X}{\sqrt{n}}} \quad (1)$$

In this test, n is the number of samples, $\mu$ represents the t distribution with n degrees of freedom when the hypothesis is true, $\sigma$ is the standard deviation,

$$t = \frac{\overline{d} - \mu_0}{s_d / \sqrt{n}} \quad (2)$$

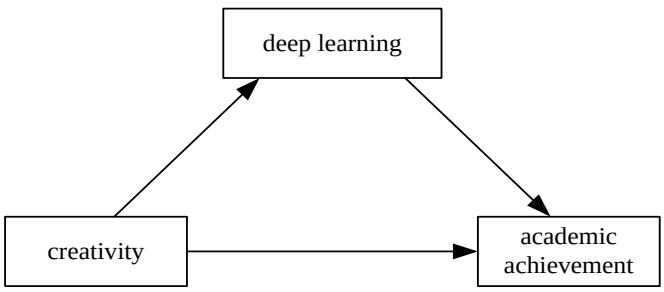
where $\overline{d}$ is the paired sample mean, and $s_d$ is the standard deviation, $\mu = \mu_0$.

## 3. Methodology

### 3.1. Establishing a Theoretical Model

According to the research content of this paper, the relationship between deep learning, academic performance and creativity is established as shown in Figure 1.

**Figure 1.** *Theoretical Model to Study the Relationship between Variables;* **source:** *Original Research*



### 3.2. Formulating the Research Hypotheses

This paper studies the relationship between three variables of CS' creativity, AA and DL style. It is not only necessary to explore the direct impact of CS' creativity on AA and DL methods, but also whether DL methods play a mediating role in the impact of CS' creativity on AA. This includes determining whether there are differences in AA in terms of gender and place of origin. According to the research content, this research proposes the following hypotheses:

H1: The creativity of CS is related to the AA of CS, and the creativity of CS has a significant positive impact on the AA of CS;

H2: The creativity of CS is related to the way of DL of CS, and the creativity of CS has a significant positive impact on the way of DL of CS;

H3: The DL style of CS is related to the AA of CS, and the DL style has a significant positive impact on the AA of CS;

H4: CS' DL style plays a mediating role in the relationship between CS' creativity and AA;

H5: There are significant gender differences in CS' creativity, DL methods and AA;

H6: There are significant differences in CS' creativity, DL methods and AA in the source of students.

### 3.3. Determining the Research Method

The questionnaire survey method used in this paper involved randomly selecting 500 college students in a general institution of higher learning and inviting them to complete the questionnaire. The random sampling method of this student is stratified sampling, that is, 125 students in each grade were selected from the students from the first to the fourth year of the school. The questionnaire response rate was 100%, so there is no need to eliminate invalid questionnaires. According to the results, boys account for 58.3%, girls account for 41.7%, students from rural areas account for 65.4%, and students from urban areas account for 34.6%.

### 3.4. Determining the Scale

#### 3.4.1. College Students' Creative Power Scale

Some indicators of creativity can be measured by tools, but some are not easy to measure directly, such as creative motivation and creative awareness (Chen & Mallak, 2021; Liu, 2019). Some scholars have combined the research results of domestic and foreign scholars and divided the evaluation of CS' creativity into three secondary indicators and 11 third-level indicators. These include creative personality tendency and creative behaviour ability (Zhang, 2019; Zheng, 2018).

#### 3.4.2. DL Scale for CS

According to the guidance of DL theory, the DL scale can include reflective learning, integrated learning, and cooperative learning. This study selects these three indicators and their associated items to evaluate DL (Lim, 2019; Gipson & Mitchell, 2017).

3.4.3. AA of CS

In previous studies of AA, whether conducted as quantitative or qualitative research, it has been related to achievement evaluation (Wilcox & Nordstokke, 2019). For CS, many scholars have proposed a comprehensive evaluation from various aspects. However, we believe that, as far as the current teaching situation in CAU is concerned, the most objective indicator to reflect students' AA is the students' academic performance (Shen, Ma & Guan, 2019). Therefore, to analyze similar studies, we chose to take the average grades of CS' compulsory courses in the semester as an indicator to reflect the AA of CS (Cho, Bak & Gim, 2020; Ijrish & Al-Rubaie, 2018).

## 4. Results and Discussion

### 4.1. Questionnaire Reliability and Validity Analysis

SPSS 25.0 was used to test the reliability and validity of the questionnaire, and the results are shown in Table 1. Cronbach's alpha was used to test the reliability of the questionnaire. The reliability of creativity, AA, and DL methods were 0.901, 0.895, and 0.937, respectively, all greater than 0.8, indicating that the reliability of the scale was very good enough to support this study. In this study, we used a factor analysis method for the construct validity of the questionnaire. Factor analysis (FA) mainly separates or extracts common factors from the items measured in the questionnaire to obtain the construct validity of the scale (Wang *et al*., 2018). Before FA, we first performed KMO and Bartlett sphericity tests on the questionnaire to judge whether the questionnaire was suitable for FA. Through SPSS software, we calculated the survey data. The data with KMO value less than 0.5 is not suitable for FA. If the value is greater than 0.6, it is suitable for FA. KMO and Bartlett tests were used for validity verification. The KMO values were 0.894, 0.872 and 0.948, and the KMO values were all greater than 0.8, which were suitable for FA (Sun *et al*., 2018). The Bartlett sphericity test results also showed a significance level of $P=0.000<0.001$. Therefore, all three scales passed the construct validity test. In conclusion, the three scales used in this study have good reliability and validity, and can be further studied and used.

**Table 1.** *Summary of Reliability and Validity;* **source:** *Original Research*

| | Method | Creativity | AA | DL |
|---|---|---|---|---|
| Reliability | Cronbach's alpha | 0.901 | 0.895 | 0.937 |
| Validity | The number of KMO sampling | 0.894 | 0.872 | 0.948 |
| | Bartlett test of sphericity significance | 0.000 | 0.000 | 0.000 |
| | VE | 67.308% | 74.125% | 63.849% |
| | Factor Loadings | 0.654-0.717 | 0.695-0.826 | 0.741-0.853 |

### 4.2. Structural Equation Model Test

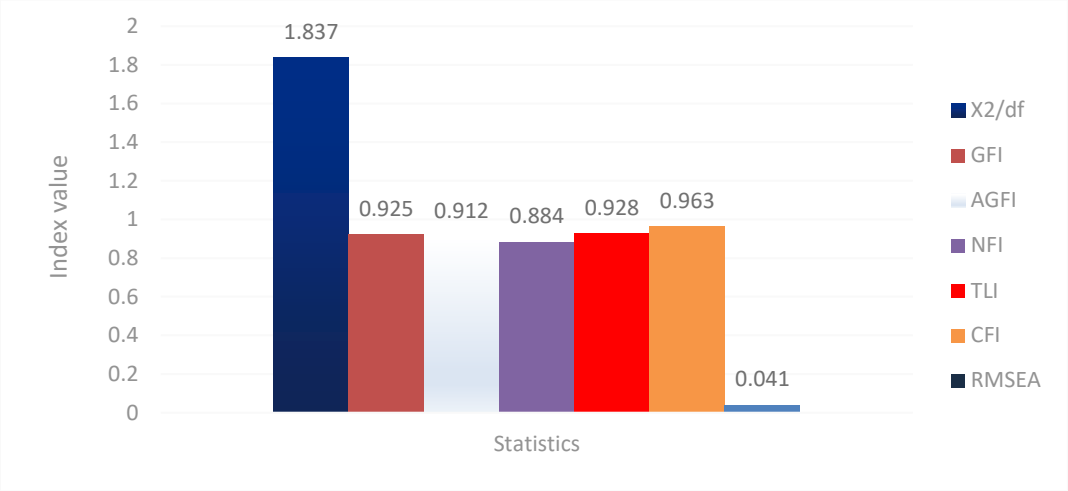
4.2.1. Model Fit Analysis

AMOS software was used to generate a structural equation model with path coefficients, and the path effects were analyzed to investigate H1, H2, and H3. In order to evaluate the external quality of the structural equation model, Liu and Yang (2018) believed that the absolute fitness index (FI), the value-added FI, and the parsimonious FI should be considered. The main statistics of the FI include chi-square degrees of freedom $\chi^2$, RMSEA, GFI, and AGFI. The fluctuation of $\chi^2$ is easily affected by the size of the sample. If

the sample is too large, the $\chi^2$ tends to become larger, and it is easy to reject the null hypothesis and accept the opposite. In contrast, the RMSEA value is not easily affected by the sample size, and its value is less than 0.05, indicating a good model fit, and it is acceptable between 0.05 and 0.08. GFI is equivalent to $R^2$ in compound regression, while AGFI is adjusted GFI. The larger the two, the better the model fit. The standard is generally greater than 0.9, and some scholars believe that it can be relaxed to 0.85, indicating the model path map and actual data. There is a good fit; the value-added fitness indicators mainly include TLI and CFI, among which the TLI value is lower than other indicators, and it is easy to show that other indicators show good fitting results, but TLI is not ideal, and CFI fits the hypothetical model. The degree of estimation is stable, and its standard is generally above 0.9, but it can also be relaxed to 0.85; NFI is representative of the parsimony fit index, which is used to judge the degree of simplification of the structural model (Zhou, 2018; Zhou & Ma, 2019). Therefore, this paper uses GFI, AGFI, NFI, TLI, CFI, RMSEA indicators to evaluate the fit of the model.

The next step was to perform structural equation analysis on models of college students' creativity, academic achievement, and deep learning styles, and optimize and correct incorrect terms. The model fitting results are shown in Figure 2.

**Figure 2.** *Model Fitting Results;* **source:** *Original Research*




The results in Figure 2 show that the chi-square DOF ratio is 1.837 < 3.000, indicating a good model fit. From other fitness indicators, the GFI value is 0.925, the AGFI value is 0.912, the NFI value is 0.884, the TLI value is 0.928, the CFI value is 0.963, and the RMSEA value is 0.041, all within the general standard range, and the model fits well, indicating that the theoretical model is in good agreement with the actual data, and the model is convincing.

4.2.2. Model Path Analysis

S.E. is the standard error of the estimated parameter; C.R. is the statistic of the Z test. When the absolute value of the Z value is greater than 1.96, it means that the path coefficient (PC) is significant at the 0.05 level; The PC is significant at the 0.001 level, which is represented by the symbol "***". When $p<0.01$, it means that the PC is significant at the 0.01 level, which is represented by the symbol "**". When $p<0.05$, it means that the PC is in the 0.01 level. Significant at the 0.05 level, denoted by the symbol "*", when $p>0.05$, it means that the PC is not significant, denoted by the symbol "-". The model standard PC of the research model are shown in Table 2.

**Table 2.** *Standard PC for the Model;* **source:** *Original Research*

| Path | Estimate | S.E. | C.R. | *p* |
|---|---|---|---|---|
| Average grade for required courses<— Creative thinking skills | 0.312 | 0.037 | 2.583 | *** |
| Average grade for required courses<— Creative personality tendencies | 0.246 | 0.051 | 4.319 | *** |
| Average grade for required courses<— Creative capacity | 0.243 | 0.045 | 3.746 | *** |
| Deep learning method<—Creative thinking skills | 0.298 | 0.049 | 5.326 | *** |
| Deep learning method<—Creative personality tendencies | 0.156 | 0.027 | 2.915 | *** |
| Deep learning method<—Creative capacity | 0.374 | 0.055 | 5.842 | *** |
| Average grade for required courses<— Deep learning method | 0.253 | 0.081 | 3.706 | *** |

It can be seen from Table 2 that the standardized coefficients of the three dimensions of creativity on the average grades (AA) of compulsory courses are 0.312, 0.246, 0.243, $p<0.001$, indicating that creativity has a significant positive impact on academic achievement. Assuming that H1 is supported; the standardized coefficients of the three dimensions of creativity to deep learning methods are 0.298, 0.156 and 0.374, $p<0.001$, indicating that creativity has a significant positive impact on deep learning methods. It is proved to be effective; the standardized coefficient of deep learning method on the average grade (AA) of required courses is 0.253, $p<0.001$, indicating that DL method has a significant positive impact on AA, assuming that H3 is supported.

4.2.3. Mediating Effect Analysis

Based on the results of the path analysis, a hypothesis test is established. To explore whether there is a mediating effect on these significant paths, the Bootstrap method was run in AMOS, repeated 5000 times, with a confidence level of 95% for the interval standard and bias correction method for testing. The results of the Bootstrap test are shown in Table 3, and the mediation effect value is between 0.034 and 0.158. The confidence interval test shows that the confidence interval does not contain 0, so it can be indicated that the hypothesis H4 is supported, that is, the DL method has a mediating role in the relationship between CS' creativity and AA.

**Table 3.** *Bootstrap (95%) Mediation Effect Test;* **source:** *Original Research*

| The Path | Effect of value | S.E. | Bootstrap (95%) |
|---|---|---|---|
| Creative thinking skills—> DL method—> Average grade for required courses | 0.034 | 0.071 | (0.025,0.084) |
| Creative personality tendencies—> DL method —>Average grade for required courses | 0.158 | 0.066 | (0.090,0.261) |
| Creative capacity—> DL method—> Average grade for required courses | 0.073 | 0.032 | (0.045,0.178) |

4.2.4. Significant Difference Analysis

With a significance level of 0.05, when $p<0.05$ the null hypothesis ($H_0$) is rejected, there is a SD in the overall population; when $p>0.05$ $H_0$ is not rejected and it is concluded that there is no overall difference. As shown in Table 4, there are significant differences detection results. It can be seen that $p<0.05$, assuming that H5 and H6 are true, that is, there are significant differences in the creativity, deep learning style and academic achievement of college students in terms of gender and student origin.

**Table 4.** *Significant Difference Detection*; **source:** *Original Research*

| | Gender | | Birthplace | | *p* |
|---|---|---|---|---|---|
| | Male | Female | Rural | City | |
| Creativity | 3.250 | 3.180 | 2.070 | 2.140 | 0.010* |
| DL method | 5.420 | 5.490 | 3.820 | 3.750 | 0.028* |
| AA | 1.960 | 1.830 | 3.340 | 3.460 | 0.003** |

### 4.3. Suggestions for Promoting the Sustainable Development of CS

4.3.1. Innovative Educational Methods to Cultivate Students' Creativity

Creativity is the comprehensive performance of an individual's multi-faceted abilities. A person must have creative actions, not only a broad knowledge base, but also an innovative personality; not only must the individual have long-term deep thinking on certain types of problems, but also must have a sudden epiphany that creates the flash of thinking; it is necessary to concentrate the wisdom of the group, but also the independent thinking of the individual; it needs not only the drive of external motivation, but also internal motivation and original creative impulse. Creative thinking is not only the unity of memory thinking and manifest thinking, the unity of intuitive thinking and reasoning thinking, but also the unity of divergent thinking and convergent thinking.

Therefore, the cultivation, formation and development of creativity is a certain process, not a simple one-step event. People's performance characteristics and growth cycles are different, and they have their own laws. This is consistent with the conclusion that students' individual differences have a profound impact on creativity in previous studies, that is, students with different genders and places of origin have different creative performances, which in turn leads to differences in AA. The cultivation of creativity can not only be solved by the creation of the principles of creativity courses or the courses of creativity techniques, although they can also play a certain role. Paying attention to (PAT) the cultivation of students' creativity is actually PAT the development of students' academic harvest and overall quality from a higher level, it also shows that creativity has a significant impact on the AA of CS.

4.3.2. Innovate Learning Methods and Give Full Play to the Mediating Role of DL

CAU should innovate in-depth learning methods. For example, inquiry learning is to let students think with questions, and reflective learning is to allow students to reflect on what they have learned and what they are missing after the learning process. Through these types of learning methods, it can provide students with a direction for thinking about problems, let students go to the root of the problem, stimulate students' desire to explore knowledge, and help students develop creative thinking and imagination. It is the role of DL that students develop the habit of independent thinking, and it is also a manifestation of the mediating role of DL in promoting students' creativity and thus affecting academic performance. Therefore, the mediating effect of DL to improve the academic level of CS is not only conducive to college students' recognition of their own learning ability, but also to diversify students' creative thinking and improve their creative ability.

## 5. Conclusion

Based on the four hypotheses proposed in this study, the following conclusions are made:

*There is a significant positive correlation between CS' creativity and AA*

The data shows that the influence coefficient of creative thinking ability on AA is 0.312, the influence coefficient of creative personality tendency on AA is 0.246, and the influence coefficient of creative behaviour ability on AA is 0.243, which shows that the creativity of CS will be affected to a certain extent. This affect students' performance in school and thus has an impact on students' AA. Generally speaking, students with good creativity will be more concerned about others whether in campus life or in social life. Since creative students have unique personality and charm, they have unique opinions in handling things, dare to ask questions, and can solve problems by themselves, so the academic achievement of such students will be relatively outstanding. Studies have shown that creative tendencies such as risk-taking, curiosity and imagination can have an impact on AA. In terms of imagination and curiosity, the curiosity displayed by students with good AA is not only reflected in learning, but also in life. Students with poor AA tend to have weaker exploratory ability and thirst for knowledge, and lack space for innovation in imagination. Therefore, the impact of creativity on AA is significantly and positively correlated.

*The creativity of CS has a significant positive correlation with DL methods*

This study shows that the standardized coefficients of creative thinking ability, creative personality tendency, and creative behaviour ability to DL methods are 0.298, 0.156 and 0.374, respectively, which indicates that CS have a strong vision to improve their creative ability, and they need the school to provide more opportunities to innovate, coupled with teacher coaching to boost creativity. At the same time, the way of thinking of creative students in dealing with things is different from that of ordinary students. For example, some students may choose to give up if they cannot solve a certain problem, but some students take the result of the problem as the ultimate goal. By looking for materials and constantly reflecting, one

can finally get a satisfactory answer. This is the impact of DL methods on students, enabling them to maintain their perseverance.

*DL methods have a significant positive correlation with AA*

The standardized coefficient of DL method on AA is 0.253, indicating that the learning method of CS is a key factor affecting academic performance, and students can improve their academic performance through DL. Pay will be rewarded. Students make efforts in learning, and the reward to students must be grades. However, each student has different characteristics and learning characteristics. Therefore, the students who are suitable for them are also different and require an appropriate learning method in order to maximize the effectiveness of learning and improve students' academic achievement.

*DL mode has a mediating role in the relationship between CS' creativity and AA*

This study shows that the mediating effect value of DL in the impact of creativity on academic performance is between 0.034 and 0.158, indicating that college students can improve creativity and AA through deep reflective learning and cooperative learning.

*There are significant differences in the creativity, in-depth learning methods and AA of CS in terms of gender and origin.*

The results of the significant differences between gender and origin of students in this paper show that gender and origin are the reasons for students to have different creative abilities, different learning styles, and high and low academic performance. Generally speaking, boys' creative thinking ability is stronger than girls', which may be a natural advantage of boy' logical thinking or because they are given more and better opportunities to learn. Children born in cities have a much better family structure than rural children in terms of wealth and status. Parents of urban children commonly permit their children to enroll in interest classes and so cultivate their creativity from an early age. Therefore, gender, and student origin are also factors that cause students to have different creativity, in-depth learning methods, and AA.

To sum up, in order to realize the sustainable development of college students, suggestions are put forward to help students improve their academic performance and enable them to develop actively from the perspectives of creativity and DL.

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