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A Study of the Effects of Living Space Design on Learning Motivation and Mental Health of Elementary and Middle School Students

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Abstract Living space is an important place for primary and secondary school students to grow and study, and its influence on primary and secondary school students in terms of layout and color design has gradually become a hot research topic. In this paper, the mental health level of primary and secondary school students is taken as the explanatory variable, and the living style and living environment are taken as the core explanatory variables. A multiple linear regression prediction model is introduced to explore the linear relationship between multiple variables. A total of 7,063 valid data sources were obtained by distributing questionnaires online. The overall study motivation of the sample was statistically analyzed, and the multiple linear regression prediction model was further used to analyze the correlation between living space design and study motivation. The research samples were selected and the proposed predictive model was used to conduct regression analysis of multiple variables with the mental health status of primary and secondary school students. Among them, $P<0.05$ was found between the living space design and the learning motivation and mental health status of primary and secondary school students, indicating that a reasonable living space design can have a positive impact on the learning motivation and even the development of mental health of primary and secondary school students.

Index Terms living space design, multiple linear regression prediction, mental health, learning motivation, primary and secondary school students

I. Introduction

In today's education, the amount of time that students spend studying at home is gradually increasing, especially after the introduction of the "double reduction" policy. As we all know, the learning environment of students is one of the most important factors affecting learning effectiveness and mental health. In home study, if the environment in the space is noisy, family members often quarrel, etc., it will affect the human brain thinking, disturbing the students to concentrate on the state of learning, thus affecting the learning efficiency, and at the same time, it will have an impact on the level of students' mental health, anxiety, irritability, stress and other bad emotions [1]-[3]. In the study space, strong direct light will make people feel irritable, thus affecting judgment. Low light not only affects one's vision, but also one's reduced brain response [4], [5].

In addition, temperature and humidity in the learning space can affect students' desire to learn and mental health [6], [7]. However, students who study in comfortable environments (warm, well-lit, and quiet environments) tend to be more susceptible to fatigue, or people tend to be in a relaxed or slackened state of mind because of the overly comfortable environment [8]. However, learning is a behavior that requires concentration, which inevitably leads to conflict, resulting in students' learning efficiency naturally not being too high. Focusing on the level of mental health, whether it is work, study or living environment, the design and layout of architectural space can have a direct impact on people's mood, attention and behavior, bright and spacious houses often make people feel relaxed and comfortable, while small, crowded space is easy to make people feel anxious and depressed [9]-[12].

Several studies have shown that space design with natural light, indoor green plants and good ventilation conditions can promote people's concentration and enhance the desire to learn, while chaotic environments often distract people's attention, making it difficult for them to concentrate on tasks and reducing learning efficiency [13], [14]. It can be seen that the design of living space has an important impact on students' learning and mental health.

This paper firstly describes the data sources and characteristics of the study, identifies the explanatory variables, core explanatory variables, and control variables. Secondly, it elaborates the arithmetic process and calculation formula of multiple linear regression prediction model as the research analysis method. Meanwhile, a total of 7063

research data samples are identified in the form of online questionnaires. Combing the sample data again to summarize the overall learning motivation of the research participants. Using multiple linear regression prediction model, correlation analysis between living space design and learning motivation and regression analysis between trainees' factors and learning motivation were conducted. Finally, the overall mental health status of the descriptive subjects was statistically described, and the regression analysis of the relationship between the multivariate factors and the mental health of elementary and secondary school students was unfolded using multiple linear regression predictive modeling.

II. Data sources and variable setting

II. A.Data sources

The data used in this paper come from the 2020 Tracking Survey on Factors Influencing the Mental Health of Chinese Elementary and Middle School Students, which was organized and implemented by the Health and Development Research Center of a university. The survey adopts a random sampling method and covers urban and rural primary and secondary school students in 631 cities and 23 provinces in China, which is representative and scientific, and the quality of the data is recognized by many scholars. In this paper, primary and secondary school students aged 6-15 years old were selected as the research object, and 7508 valid samples were obtained after eliminating the samples with missing values.

II. B.Variables and Operationalization

(1) Explanatory variables

The explanatory variable is the mental health level of primary and secondary school students. Existing studies commonly use depression, loneliness and other indicators to measure mental health, this paper, based on reference to previous relevant studies, combines the survey content in the questionnaire to select seven questions in the section of personality and emotional characteristics, including both positive and negative mental content to measure. Positive mental health detects primary and secondary school students' optimism, responsibility, self mastery and view of the future. Negative mental health measures the level of nervousness, sense of loss of self-efficacy, and sense of disorientation among elementary and secondary school students. Each question was scored from 0 to 5 points, and the options for the negative psychology questions were reverse coded to maintain directional consistency, with a total score of 0 to 30 points, with the higher the score the higher the level of mental health.

(2) Core explanatory variables

The core explanatory variables of this paper are living style and living environment. The mode of residence was determined by the questions “Who do you live with now” and “Relationship between co-residents and primary and secondary school students”. Based on previous studies and the questionnaire, the types of living styles were categorized into five types: living with biological parents only, living with grandparents, living with three generations, other, and living alone. Residential environment included social network support situation, housing environment and community environment. Sources of social network support were detected partly with reference to the Social Network Related Scale, which measures for the purpose of identifying social isolation how many family members or friends the respondent is able to contact and get help from, and if fewer people are able to be involved, they are considered to be at risk of social isolation. Therefore the relevant questions in the questionnaire were selected and the options were reorganized into four categories: relatives only, friends only, relatives and friends, and no one. The housing environment investigated the type of dwelling and living space, i.e., “what type of dwelling is the current one” and “whether there is a separate bedroom”. Community environment investigates the number of services provided in the community, with a scoring range of 0-9 points.

(3) Control Variables

Control variables include gender, age, type of urban and rural areas, grade of schooling, physical health status, family income status, and living conditions. The type of residence of the interviewed primary and secondary school students was categorized as urban and rural. Physical health status was measured by self-assessed health status and level of self-care ability in daily life, with self-assessed health status categorized into three levels: good, fair, and bad, and self-care ability level categorized into very restricted, restricted, and unrestricted. Household income is measured by the level of household income and “whether the income is sufficient”. Living conditions were categorized as “easy and happy”, “dull and uneventful” and “high-pressure and injured”.

III. Multivariate linear regression prediction model and research object

III. A. Multiple linear regression prediction model

Multiple linear regression model as the name suggests is to study the relationship between a dependent variable and multiple independent variables, compared with the one-dimensional linear regression, the principle is similar,

only in the calculation is more complex. If we assume that the dependent variable is y, and we need to explore the linear relationship between the dependent variable y and n independent variables $x_1, x_2, \cdots, x_n$, then its general multiple linear regression formula is shown in equation (1):

$$y = \sum_{i=1}^{n} b_i x_i + b_0 + \varepsilon \tag{1}$$

where b_i denotes the partial regression coefficient of its corresponding independent variable in the sample, which means the amount of change in the dependent variable y averaged over a unit change in the independent variable. b_0 is a constant that represents the intercept. ε is the random error after removing the effect of n independent variables on the dependent variable y, also known as the residual, which is an unobservable random variable. If there are m sets of observations, substituting them into the general formula yields equation (2):

$$\begin{cases} y_1 = b_0 + b_1 x_{11} + b_2 x_{12} + \cdots + b_n x_{1n} + \varepsilon_1 \\ y_2 = b_0 + b_1 x_{21} + b_2 x_{22} + \cdots + b_n x_{2n} + \varepsilon_2 \\ \vdots \\ y_m = b_0 + b_1 x_{m1} + b_2 x_{m2} + \cdots + b_n x_{mn} + \varepsilon_m \end{cases} \tag{2}$$

Write it in vector form as in equation (3):

$$\begin{cases} y = [y_1 \ y_2 \cdots y_m]^T \\ X = \begin{bmatrix} 1 & x_{11} & x_{12} & \cdots & x_{1n} \\ 1 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & & & & \\ 1 & x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \\ b = [b_0 \ b_1 \cdots b_n]^T \\ \varepsilon = [\varepsilon_1 \ \varepsilon_2 \cdots \varepsilon_m]^T \end{cases} \tag{3}$$

Then equation (2) can be written as equation (4):

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_m \end{bmatrix} = \begin{bmatrix} 1 & x_{11} & x_{12} & \cdots & x_{1n} \\ 1 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & & & & \\ 1 & x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \begin{bmatrix} b_0 \\ b_1 \\ \vdots \\ b_n \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_m \end{bmatrix} \tag{4}$$

Eq. (4) can then be expressed as Eq. (5):

$$y = Xb + \varepsilon \tag{5}$$

where the vector of partial regression coefficients b is the unknown parameter and ε is the residual. In general X is referred to as an information matrix of order $m \times (n+1)$, assuming that X is column-full rank, i.e., equation (6):

$$rank(X) = 1 + n \tag{6}$$

Eq. (6) denotes the rank of the matrix X, and Eq. (5) is a classical linear algebra formula aimed at solving the model for the vector of partial regression coefficients b.

III. B. Subjects of the study

In this study, a questionnaire was administered to 7,508 primary and secondary school students from October 15, 2023 to December 15, 2023 using a convenience sampling method and an online platform. The students themselves and their guardians signed an informed consent form. A total of 7485 questionnaires were finally collected, of which 7063 were valid and the validity rate of the questionnaires was 94.36%.

IV. Regression analysis of living space design on different variables

IV. A. Analysis of the impact of living space design on learning motivation

IV. A. 1) Overall motivation for learning

In this section, the classic criterion for determining the strength of learning motivation in academia was used to conduct the study on the level of learning motivation of the study participants. When the average of the overall scores of the Motivation for Learning Questionnaire is between 0.0-2.4, it means that the strength of motivation for learning is weak. When the average of the overall scores of the Motivation Questionnaire is between 2.5-3.4, it means that the motivation level of primary and secondary school students is at a medium level. When the average of the overall scores of the motivation questionnaire is between 3.5 and 5.0, it means that the motivation strength of primary and secondary school students is very high. In this paper, based on the existing research, learning motivation is divided into the following four categories: (S1) I study because of personal interest, (S2) I study because my parents ask me to, (S3) I study because I want to self-improvement, and (S4) I study out of social needs, and the results of the level of learning motivation of primary and secondary school students are shown in Table 1.

Table 1: The learning motivation level of primary and secondary school students

	N	Maximum	Minimum	Average	Standard deviation
S1	7063	2	5	3.96	1.026
S2	7063	3	5	4.58	0.665
S3	7063	1	5	4.06	0.932
S4	7063	1	5	3.89	0.929
Total	7063	2	5	4.12	0.888

The overall mean value of the study participants' motivation to study was 4.12, which, when combined with the above guidelines, shows that the intensity of motivation to study is very high among primary and secondary school students. In addition, from the perspective of the individual study motivation means, it can be seen that the four study motivation intensities are ranked from high to low as follows: (S2) I study because of my parents' requirements (4.58) > (S3) I study because I want to self-improvement (4.06) > (S1) I study because of my personal interest (4.96) > (S4) I study because of social needs (4.89). It can be seen that the current study behavior of primary and secondary school students mainly originates from the cultivation and requirements of their parents, indicating that the families of most primary and secondary school students pay more attention to their children's study development.

IV. A. 2) Correlation analysis between living space design and learning motivation

The correlation coefficients between living space design and learning motivation are shown in Table 2, where r=>0,P=0.000<0.01, indicating that there is a significant positive correlation between learning motivation and living space design factors. That is, the more the design of living space meets the growth needs of primary and secondary school students, the stronger the motivation of primary and secondary school students to study and the easier it is for them to persist, and vice versa. Accordingly, it is recommended that families should listen to the opinions and needs of primary and secondary school students when designing and improving their living space, and take into account the actual situation to design a living space that best meets the needs of primary and secondary school students, so as to provide a suitable environment for the psychological development of primary and secondary school students.

Table 2: Correlation analysis of Curriculum Factors and Learning Motivation

		Learning motivation	Residential space design
Learning motivation	Pearson correlation	1	0.568***
	Significance (double tail)		0.000
	Number	7063	7063
Residential space design	Pearson correlation	0.568***	1
	Significance (double tail)	0.000	
	Number	7063	7063

Note:*** At the 0.01 level (double tail), the correlation is significant

IV. A. 3) Regression analysis of learner factors and motivation to learn

In this subsection, we try to explore whether there is a linear relationship between primary and secondary school students' own factors and learning motivation through regression analysis, and plot the relationship between their own factors and learning motivation in Fig. 1. It can be seen that none of the primary and secondary school students' own factors and learning motivation are linear, which proves that it is not possible to conduct linear regression analysis to construct a regression equation model. This means that because primary and secondary school students are still in the developmental stage, their worldview, values and other ideas are not yet mature, and they are more susceptible to the influence of external environmental factors. Therefore, schools and families, as the important growing environment for primary and secondary school students, should actively take the responsibility of education and cultivation for primary and secondary school students. Students should be effectively guided to establish the correct learning cognition of primary and secondary school students, to promote the improvement of the knowledge system of primary and secondary school students, and build a healthy mental state. In addition, families also need to pay attention to the design and provision of living space to provide children with a good space for growth.

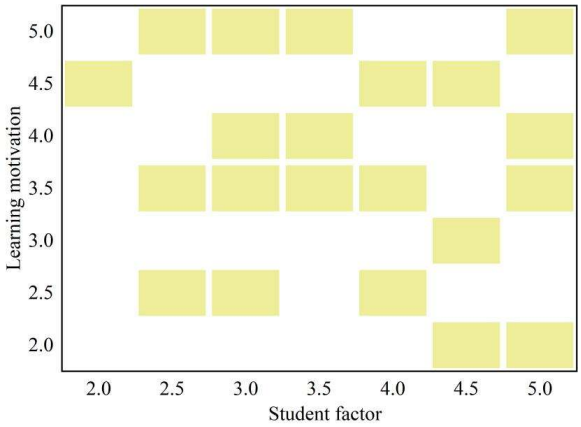

Figure 1: The linear relationship between learning motivation and student factors

IV. B. Analysis of the impact of living space design on mental health status

IV. B. 1) Mental health status of survey respondents

The SCL-90 scale was used to measure the mental health status of the survey respondents, comparing the mean scores of the SCL-90 dimensions of the survey respondents in this paper with the norms of Chinese primary and secondary school students are shown in Table 3. The results showed that (P1) somatization, (P2) obsessive-compulsive, (P3) interpersonal sensitivity, (P4) depression, (P5) anxiety, (P6) hostility, (P7) phobia, (P8) paranoia, and (P9) psychoticism among the respondents of this paper were not statistically different from the norms of Chinese primary and secondary school students (P>0.05).

Table 3: The comparison of the mental health of the survey subjects with the norm

Program	Textual	Norm	t	P
P1	1.51±0.49	1.62±0.75	8.781	0.06
P2	2.04±0.63	2.15±0.89	4.637	0.076
P3	1.94±0.61	2.05±0.88	2.348	0.072
P4	1.82±0.60	1.93±0.87	5.588	0.066
P5	1.67±0.55	1.78±0.82	7.015	0.073
P6	1.67±0.62	1.78±0.85	7.043	0.07
P7	1.44±0.49	1.55±0.76	13.785	0.053
P8	1.78±0.62	1.89±0.8	0	0.072
P9	1.65±0.54	1.76±0.83	4.508	0.051

IV. B. 2) Regression analysis of different variables in relation to students' mental health

In this section, the results of regression analysis of coping styles and life events on the mental health status of primary and secondary school students based on the multiple linear regression prediction model are shown in Table 4.The selected coping styles are (Z1) withdrawal, (Z2) fantasy, (Z3) self-blame, (Z4) asking for help from

family/school/buddies, (Z5) rationalization, and (Z6) autonomous problem solving, and the life events are (L1) poor test scores ideal, (L2) conflicts with classmates, (L3) feeling that school teachers do not care about them, (L4) bad family environment, (L5) suffering from youthful emotional problems, (L6) self-perception bias, (L7) worrying about not graduating properly, (L8) having to be separated from friends due to graduation, (L9) having more difficulty in adapting to the new circle of friends in the classroom, and (L10) frequent conflicts and clashes among family members, (L11) Complex and tense relationship with family members, (L12) Tension with parents, (L13) Dissatisfied with the layout of living space, (L14) No separate living space, and (L15) Living space has a more serious impact on daily behavior. Among them, (L10)-(L12) are living style influences, and (L13)-(L15) are living environment influences.

Table 4: Regression analysis results

Program	Regression coefficient	Standard error	z	Wald x2	P	OR	95%CI
Z1	0.405	0.306	2.123	3.901	0.015	0.405	0.915~1.326
Z2	0.29	0.296	1.132	1.07	0.031	0.29	0.962~1.356
Z3	0.313	0.282	1.571	2.082	0.021	0.313	0.521~1.515
Z4	0.091	0.28	-1.13	1.965	0.023	0.091	0.633~1.212
L1	0.074	0.304	-0.995	1.625	0.431	0.074	0.644~2.589
L2	0.105	0.275	-1.038	1.729	0.415	0.105	0.033~3.265
L3	0.656	0.441	2.089	3.772	0.258	0.656	0.419~2.746
L4	0.652	0.475	1.841	2.895	0.3	0.652	0.541~2.852
L5	0.37	0.475	0.82	0.585	0.734	0.37	0.566~2.023
L6	0.225	0.426	0.314	0.212	1.108	0.225	0.561~1.987
L7	0.177	0.457	0.113	0.206	1.131	0.177	0.053~1.999
L8	0.894	0.482	2.656	6.235	0.213	0.894	0.254~2.026
L9	0.466	0.485	1.133	1.071	0.549	0.466	0.331~2.486
L10	0.119	0.423	-0.156	0.325	0.002	0.119	0.485~1.012
L11	0.344	0.487	0.703	0.453	0.042	0.344	0.582~1.222
L12	0.405	0.306	2.123	3.901	0.024	0.405	0.519~1.298
L13	0.29	0.296	1.132	1.07	0.046	0.29	0.42~1.245
L14	0.313	0.282	1.571	2.082	0.04	0.313	0.872~1.326
L15	0.091	0.28	-1.13	1.965	0.012	0.091	0.819~1.331

It can be found that four coping styles, as well as three residential style influences and three residential environment influences, have a significant effect on the mental health status of primary and secondary school students (P<0.05). Accordingly, it can be seen that family environment is an important factor influencing the mental health status of primary and secondary school students. Parents need to focus on the way of coping with life events in the education and training of primary and secondary school students, and also need to maintain harmony among family members and a clean and comfortable living environment.

V. Conclusion

In this paper, under the support of multiple linear regression predictive modeling method, a total of 7063 primary and secondary school students' questionnaires were used as research data, and linear regression analyses of living space design on primary and secondary school students' learning motivation and mental health status were carried out successively.

In terms of learning motivation, the mean value of overall learning motivation of the research sample is 4.12, and there is a significant positive correlation between living space design and primary and secondary school students' learning motivation with r=>0, P=0.000<0.01. It indicates that good living space design can effectively promote the learning motivation of primary and secondary school students. In terms of mental health relationships, the overall mental health status of the study sample was not statistically different from the norms of Chinese primary and secondary school students (P>0.05). Moreover, a variety of living styles and residential environment influences had a significant effect on primary and secondary school students (P<0.05). Accordingly, this paper suggests that in the growth process of primary and secondary school students, parents, as the first guardians, not only need to provide the correct guidance and accompaniment in education and training, but also need to take into account the physical and mental health of their children in the construction and maintenance of the living space and mode, in order to protect the children's learning development and mental health.

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