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Research on key influence factors of creativity development of applied undergraduates based on PCA

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Abstract

Creativity is one of the core characteristics of talent; for this reason, the creativity development of applied undergraduates should be one of the basic components of their education. This article gives an overview of the meaning of the creativity of applied undergraduates and makes a literature knowledge-mining and expert investigation on the factors affecting the creativity development. We obtained more than 100 influencing factors, filtered out the duplicative factors, and formed the remaining factors into a questionnaire. A survey was conducted among 1460 teachers and students of some applied undergraduates in Heilongjiang Province. By using principal component analysis (PCA) to analyse the questionnaire, the key factors that affect the creativity development of applied undergraduates are obtained, and the key factors are systematically analysed. According to the results of the analysis, the specific ways and methods of the creativity development of applied undergraduates are put forward.

Keywords: principal component analysis, applied undergraduate, talent training, creativity development, influence factors

1 Introduction

The talents of applied undergraduates mainly refer to those who have profound basic theoretical knowledge, strong professional knowledge and practical ability, the ability of flexible application knowledge and certain creative ability, and good knowledge structure and communication skills [1]. Creativity mainly refers to the ability to generate new ideas and to discover and create new things, that is, to create, produce and make [2]. The creativity of applied talents is the ability to propose new inventions, new products, new technologies and even new theories, and this creativity can make new improvements, innovations and breakthroughs in the existing products, technologies and theories [3, 4].

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In the 1950s, Guilford proposed the concept of creativity [5], and since then, creativity has been concerned with the aspect of creative ability. Amabile believed that everyone has some creative ability, and it is precisely because of each person's invention and creation that human society keeps progressing [6]. According to the existing literature studies, domestic and foreign scholars start from the factors affecting the creativity development, and there are a few literature studies on the creativity development of different types of talents, most of which are carried out from a certain perspective. Christian Kandler [7] analysed the differences in people's creativity from the perspective of genetics and drew a significant conclusion: the differences in individual creativity come from the influence of the environment. Erin A. Carroll et al. [8] and William M. Bart et al. [9] presented relevant research models on how to evaluate individual creativity. Wang Tianli [10] proposed that the influencing factors of general creativity include cognition, behavioural style or personality, intrinsic motivation, environment and comprehensive factors. Wu Shijian et al. [11] studied the influence of individual creativity from the perspective of a social network. Shi Bianmei [12] studied the influence of proactive personality on undergraduates' creativity. Zhou Xinhui et al. [13] explored undergraduates' creativity in relation to the aspects of cultivating good teacher–student relationship, innovative campus culture construction and innovative management mode. This article starts from the research on the factors affecting the creativity of talents, especially for applied undergraduates, and deeply analyses the key factors which affect creativity development of applied undergraduates to provide a reference for the cultivation, education and teaching of the creativity of applied undergraduates.

2 Analysis of factors influencing creative development of applied undergraduates based on literature knowledge-mining

Taking 'applied undergraduates', 'creativity development' and 'influencing factors' as the basic keywords, this article enumerates and classifies all the factors influencing applied undergraduates' creativity development. Based on the method of literature knowledge-mining (text recognition statistics) and experts' investigation, we obtained more than 100 influencing factors and filtered out the duplicative factors [4]. The factors influencing creativity development of applied undergraduates are divided into two categories: external factors and internal factors. The external factors mainly include social factors, educational factors and environmental factors. Internal factors include intelligence factors, knowledge and skills factors, personality factors, motivation and so on. The factors affecting cultivation development in applied undergraduates by literature knowledge-mining and experts' investigation are shown in Table 1.

3 Analysis of key factors influencing the creative development of applied undergraduates based on principal component analysis

To make a comprehensive and objective analysis of the factors affecting applied undergraduates' creativity development, the principal component analysis method is adopted to convert the multi-dimensional observation factors obtained in the previous section, and the dimensionality reduction idea is used to transform the multiple factors into fewer mutually unrelated comprehensive factors, namely the key factors. A questionnaire was conducted among some applied undergraduates and experts in related fields in Heilongjiang Province. The repetitive factors were filtered out, and 53 factors were retained in the questionnaire (Table 1). A total of 1460 questionnaires were issued, 1408 were recovered, the recovery rate was 96.440%, 1379 were effective, and the effective recovery rate was 94.520%. The effective rate was 97.940%. Sample educational background: 100% undergraduate. Sample major composition: civil engineering, computer science and technology, network engineering, software engineering and so on. The questionnaire was analyzed by the principal component analysis(PCA) function of statistical software SPSS20.0.

Table 1 Important influencing factors of creativity development of applied undergraduates

Categories		Contents
External factors	Society	Culture Values, social culture, habits and customs, culture quality...
		Public opinion General mood of society, social order, open and transparent information, honour incentives...
		Interpersonal relationship Communicative ability, social network relation, a harmonious interpersonal relationship...
	Education	Higher education Teaching idea, teaching method, teaching management, university teaching management, excitation mechanism, great attention of leaders, assessment methods, innovation of teacher, student management, teaching style, teaching plan, practice teaching...
		Family education Family culture, study habit, mental and physical health...
	Surroundings	Campus culture Campus culture construction, school spirit, study style, information diversity...
		Innovation atmosphere Academic atmosphere, academic level, academic exchange, creating an atmosphere of innovation, innovation incentive, academic competition, flexible study time...
	Intelligence	Thinking way, intelligence level, insight, imagination...
	Internal factors	Knowledge and skills Knowledge structure, learning ability, information processing ability, knowledge accumulation, experience diversity, comprehensive ability, research ability, presentation skill, decision-making ability...
		Personality Emotion quotient (EQ), volitional quality, challenging, interest, teamwork, curiosity, adventure, feeling of urgency, introversion, extroversion...
	Motivation	Academic attitude, questioning spirit, self-management, independency learning, self-confidence, activeness, sense of competition...

3.1 Kaiser-Meyer-Olkin and Bartlett's test

The test statistic Kaiser-Meyer-Olkin (KMO) is used to check the partial correlation between variable indicators. The value of KMO is between 0 and 1. The closer the value is to 1, the stronger is the partial correlation between variable indicators is, and the better is the effect of factor analysis. The Bartlett sphericity test is used to test the distribution of the data. If the adjoint probability sig. value is less than 0.05, the data is spherical distribution. In our experiment, the results of the KMO test and the spherical Bartlett test are shown in Figure 1. The test statistics $KMO = 0.967$ and the adjoint probability $Sig. = 0.000$ indicate that the data have high correlation and structural validity and are suitable for factor analysis.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.967
Bartlett's Test of Sphericity	Approx. Chi-Square	31595.334
	df	1378
	Sig.	.000

Fig. 1 The result of KMO and Bartlett test.

3.2 Do factor analysis and calculate the eigenvalues of these factors

The Scree Plot of eigenvalue distribution is shown in Figure 2, in which the x-coordinate Component Number in Figure 2 is the influencing factor, and the y-coordinate is the eigenvalue of each influencing factor.

Fig. 2 Scree plot of factors influencing creativity development.

Scree Plot shows the descending eigenvalues of the influencing factors and the number of influencing factors. There are 26 factors with an eigenvalue greater than 1.0 and 27 factors with a value less than 1.0. These are (1) challenging ($\lambda = 17.256$), (2) self-management ($\lambda = 3.718$), (3) independency learning ($\lambda = 2.158$), (4) interest ($\lambda = 1.669$), (5) information processing ability ($\lambda = 1.579$), (6) information diversity ($\lambda = 1.543$), (7) knowledge accumulation ($\lambda = 1.511$), (8) study habit ($\lambda = 1.479$), (9) experience diversity ($\lambda = 1.449$), (10) comprehensive ability ($\lambda = 1.422$), (11) knowledge structure ($\lambda = 1.394$), (12) thinking way ($\lambda = 1.372$), (13) research ability ($\lambda = 1.345$), (14) teamwork ($\lambda = 1.321$), (15) flexible study time ($\lambda = 1.291$), (16) excitation mechanism ($\lambda = 1.268$), (17) presentation skill ($\lambda = 1.229$), (18) campus culture construction ($\lambda = 1.205$), (19) creating an atmosphere of innovation ($\lambda = 1.184$), (20) values ($\lambda = 1.162$), (21) self-confidence ($\lambda = 1.129$), (22) family culture ($\lambda = 1.109$), (23) intelligence level ($\lambda = 1.076$), (24) university teaching management ($\lambda = 1.056$), (25) great attention of leaders ($\lambda = 1.023$) and (26) assessment methods ($\lambda = 1.012$).

The eigenvalues of the above 26 factors cumulatively explain 80.028% of the population variance, which exceeds 80%, while the eigenvalues of the other 27 factors cumulatively explain less than 20% of the population variance, as shown in Table 2. The experiment results show that the 26 factors mentioned above (80.028% of the population variance) are acceptable, and that these are the key factors among the 53 factors influencing creativity development.

Table 2 Total variance table of factors influencing creativity development

Component	Initial Eigen values			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative%	Total	% of Variance	Cumulative%
1	17.256	32.559	32.559	17.256	32.559	32.559	3.297	6.222	6.222
2	3.718	7.015	39.574	3.718	7.015	39.574	3.010	5.679	11.900
3	2.158	4.071	43.645	2.158	4.071	43.645	2.944	5.554	17.455
4	1.669	3.149	46.794	1.669	3.149	46.794	2.845	5.367	22.822
5	1.579	2.602	49.396	1.379	2.602	49.396	2.714	5.120	27.942
...	...	...	...	...	...	...	...	...	...
22	1.109	1.130	75.836	.599	1.130	75.836	1.001	1.888	72.752
23	1.076	1.086	76.922	.576	1.086	76.922	.973	1.835	74.587
24	1.056	1.056	77.978	.560	1.056	77.978	.973	1.835	76.422
25	1.023	1.038	79.015	.550	1.038	79.015	.966	1.822	78.244
26	1.012	1.013	80.028	.537	1.013	80.028	.946	1.784	80.028
27	.917	.975	81.003						
...	...	...	...						
51	.496	.559	98.983						
52	.486	.540	99.523						
53	.453	.477	100.000						

3.3 Statistical analysis results of key factors influencing creativity development in applied undergraduates

We obtained the key influencing factors of applied undergraduate students' creativity development by using PCA, as shown in Table 3.

4 Analysis of the key factors of creativity development of applied undergraduates

4.1 External factors

External factors mainly include social factors, education factors and surroundings factors, which can not only promote the development of creativity but also limit and hinder the cultivation of creativity.

1. Society factor

(1) Culture factor: (Key factor: values) A person's values have a great influence on his life. If we cultivate creative people without proper values, their creativity is likely to do harm to the country and society.

(2) Public opinion factor: Public opinion naturally influences the development of people's creativity. The direction of public opinion will influence people's judgement and guide people's behaviour. In the absence of availability of a good social atmosphere and an open and transparent social order, people's judgement and behaviour will be seriously affected; thus, naturally, there will be no interest in invention and creation. If public opinion does not encourage creative people, naturally their creativity will be affected. This influence naturally also carries over to the youth group of the university.

(3) Interpersonal relationships factor: Interpersonal relationships also affect people's creativity development. Having a good relationship with classmates, colleagues, friends etc., especially the emergence of the social networking groups in the modern society relationship, would inspire students' inventions, which may emerge from their emotional desires. They may even obtain inspiration, methods and skills of invention and creation in the collision of ideas, which promotes the cultivation of positive thinking and the development of their creativity.

Table 3 Key factors influencing creativity development in applied undergraduates

Categories			Contents	%	
External factors (26.2%)	Society (2.2%)	Culture	20.Values	2.2	
	Education (14.2%)	Higher education	16.Excitation mechanism, 24.University teaching management	9.3	
		Family education	25.Great attention of leaders, 26.assessment methods		
	Surroundings (9.8%)		8.Study habit, 22.Family culture	4.9	
		Campus culture	6.Information diversity, 18.Campus culture construction	5.2	
		Innovation atmosphere	15.Flexible study time, 19.Creating an atmosphere of innovation	4.6	
Internal factors (73.8%)	Intelligence (4.6%)		12.Thinking way, 23.Intelligence level	4.6	
	Knowledge and skills (18.1%)	5.Information processing ability, 7.Knowledge accumulation, 9.Experience diversity, 10.Comprehensive ability, 11.Knowledge structure,13.Research ability, 17.Presentation skill		18.1	
		Personality (38.0%)		1.Challenging, 4.Interest, 14.Teamwork	38.0
		Motivation (13.1%)		2.Self-management, 3.Independency learning, 21.Self-confidence	13.1

An instance wherein a collision of ideas resulted in a successful invention is the close friendship between Bill Gates and Paul Allen, which led them to co-found Microsoft.

2. Education factor

(1) Higher education factor: Key factors are excitation mechanism, university teaching management, great attention of leaders and assessment methods. University is the main base with which to cultivate the creativity of students. Therefore, a good incentive mechanism should be established in the university, which will promote fairness and stimulate people's potential and creativity. How can a university with a low level of standard and backward teaching-management cultivate creative talents in students? To cultivate students' spirit of innovation, universities should not only have advanced management but also have advanced ideas, and the leaders and even all the members of the university must pay immense attention to it. At present, the final examination of some universities tends to be based on the evaluation criteria of standard papers and standard answers, which makes students gradually lose their creativity and forms a fixed and consistent pattern.

(2) Family education factor: (Key factors: study habit, family culture) In terms of family education, family culture is very important. Ancient people paid more attention to family traditions and family instructions; on the other hand, modern families pay more attention to the aspect of facilitating their children to get a good education, and believe that the only way out is for their children to go to universities. In addition to going to school, the child only changes from school to cram school, while ignoring the issues that are very important to the child's education: physical and mental health and the question of how to cultivate good study habits in the child. This has also led to more and more psychological problems among students. As soon as the children arrive at college, they think they have achieved their parents' goals. It is hard to imagine what inventions an unhealthy student can have, since the question arises as to whether any innovation can be expected from a university man who is satisfied merely with passing grades.

3. Surroundings factor

(1) Campus culture factor: (Key factors: information diversity, campus culture construction) Information diversity can broaden students' access to information, thereby ensuring that students can keep abreast of the latest subject knowledge, and can lay a foundation for students' innovation. Students are participants in campus cultural activities, which include extracurricular cultural activities as the main content. Inheritance and innovation are the unique attributes of campus culture. Campus culture construction takes the campus as the space for teachers and students' main activities and is a group culture which is characterised by campus spirit. Obviously, the innovation of campus culture construction is beneficial to the cultivation of students' creativity [14]. Through the rich campus culture activities, we can broaden students' knowledge, enrich their knowledge structure and enable students to give full play to their imagination and creativity.

(2) Innovation atmosphere: (Key factors: flexible study time, creating an atmosphere of innovation) The surroundings have scientific enlightenment and educational functions for a person's development; for this reason, the cultivation of creativity cannot be separated from an environment in a manner which is similar to the innovation atmosphere [15]. Tao Xingzhi, a modern educator, said, 'Everywhere is a place of creation. Every day is a time of creation. Everyone is a creative person.' This sentence clearly points out the importance of the innovation atmosphere. It is not possible to imagine how there could be creation without policy and environment support, without leaders' support, teachers' guidance and help, classmates' mutual learning, personalised learning and living space.

4.2 Internal factors

Intelligence, knowledge and skills, personality and motivation are essential internal factors for creativity development.

1. Intelligence factor

Intelligence is a prerequisite for creation: (Key factors: thinking way, intelligence level) Intelligence includes people's memory, observation, imagination, thinking, judgement and other abilities [16]. The stronger these abilities are, the higher their intelligence level will be and the easier it will be to stimulate creativity. The way of thinking lies in exploring the question of how to use intelligence and what ways and means ought to be applied to observe, imagine, think and judge. People of different nationalities and cultural backgrounds think differently. For applied undergraduates, we should fully consider their thinking mode and intelligence level, not follow the teaching of research universities, and work out the mode and course system that are in line with the development of applied undergraduates' creativity.

2. Knowledge and skills

Knowledge is the bridge between invention and creation. (Key factors: (5) information processing ability, (7) knowledge accumulation, (9) experience diversity, (10) comprehensive ability, (11) knowledge structure, (13) research ability, (17) presentation skill) A person's knowledge accumulation, knowledge structure and professional knowledge will determine the play of their creativity, but not in a direct proportion. Skill is a means of invention. It is a reflection of one's ability to collect, process, study and integrate all kinds of information in the world with one's own experience, and then to invent and create. Everyone has a certain degree of creativity, and it is not true that only those who have attended a research university because of their higher level of knowledge and skills can invent. Ma Yun, founder of Alibaba Group, founded an e-commerce platform in China, and he graduated from a local normal university. Obviously, applied undergraduates can also create.

3. Personality factor

Personality can also be called temperament or character [17], which is a prominent part of personality characteristics. (Key factors: (1) challenging, (4) interest, (14) teamwork) A man can show his strong and tenacious qualities in aspects such as emotion, will, tolerance setbacks, having a strong interest in teamwork, having the courage to challenge and having the will to stimulate the potential of creation—all of these are positive elements of creativity cultivation. In this questionnaire, teachers and students agree that challenging is the uppermost key factor which can influence creativity development. Steve Jobs dared to challenge and ushered in a new era for Apple. As an applied undergraduate, there should be a focus on cultivating students with strong will and strong

interest as well as team spirit, and on encouraging students to dare to challenge the impossible, all of which are essential factors for the development of creativity.

4. Motivation factor

Motivation is the driving force of creativity. (Key factors: (2) self-management, (3) independency learning, (21) self-confidence) To be creative, a student needs to have clear motivation and a goal. Motivation is important for creative work because it makes the individual go all out. Students' self-management, independency learning, self-confidence and other subjective positive factors that can enable them to mobilise themselves can facilitate individuals to overcome obstacles on the road ahead and allow them to go all out. Students accept new knowledge and new things quickly and dare to innovate, but if there is a lack of conscious, positive, active will, this will be out of the question. University education should understand these characteristics of students, stimulate their learning initiative and enthusiasm, cultivate their self-confidence and give full play to their intelligence to actively invent.

5 Suggestions on cultivating creativity development for applied undergraduates

Social development requires innovation, and the construction of an innovative country must also include innovation in higher education. Only innovation in higher education can cultivate talents with innovative spirit in line with the needs of national and social development. Based on the analysis of the key factors mentioned above, universities, especially applied undergraduate, should focus on reform in relation to the aspects of innovative management mode and innovative campus culture construction.

1. Reform the innovative teaching and management model in colleges and universities.

1) Teaching model reform

(1) According to the characteristics of applied undergraduates, the talent training mechanism should be innovated. Courses related to 'creativity development' should be included in the curriculum system, and the key factors of creativity development should be combined into the professional curriculum system.

(2) In the teaching process, teachers should cultivate the student-centred teaching consciousness, give play to the students' dominant position and adopt appropriate teaching methods in combination with the teaching content. For example, heuristic teaching can cultivate students' ability to raise, analyse and solve problems, and especially to cultivate students' creative spirit.

(3) The assessment and evaluation methods should be flexible and diversified, and comprehensive evaluation should be carried out.

(4) To establish a good incentive mechanism, such as cultural incentive, ideal incentive, goal incentive, success incentive, example incentive, personality incentive, care incentive, reward and punishment incentive etc., to mobilise students' enthusiasm and initiative and then stimulate students' creativity.

2) Management model reform

To improve the quality of management personnel and reform the management mechanism of applied universities. The development of university students' creativity is a systematic project, which requires a complete mechanism, and the effective operation of this mechanism requires the active participation of university administrators, who are the guarantee for the cultivation of innovative talents in universities [18]. Specific suggestions are given as follows:

(1) The management model should be built by universities, and should be suitable for the development of students' creativity including institutional improvement, supporting a reasonable organisational structure and division of labour, personnel, and so on. Research universities started earlier in this aspect, and applied undergraduates need to catch up.

(2) Innovation and Entrepreneurship Centres (Parks) and Maker Spaces should be also established by applied universities. They should strive to create an innovative atmosphere to provide organisation guarantee for the training of innovative projects and innovative talents.

2. Innovation campus culture construction

Campus culture construction plays an active role in the healthy growth of students. The connotation of campus culture construction is rich, and it includes moral cultivation of teachers and students, guidance of values and the development of various campus cultural activities. We can strengthen the construction of campus culture in relation to the aspects of environmental construction, campus activities, strengthening the importance of leadership, strengthening the construction of classes and associations, information campus construction and other key factors. Specific suggestions are as follows:

- (1) Strengthen the construction of campus cultural landscape in relation to the aspect of environmental construction. The campus cultural landscape of the university, with profound historical and cultural accumulation and inheritance, often contains encouragement, thinking and enlightenment, which are exactly what students need to cultivate their creativity.
- (2) Carry out a variety of cultural and recreational activities, scientific and technological activities and competitions, which are conducive to the development of students' creativity.
- (3) Leaders and teachers who deal with applied undergraduates need to update their ideas. Students' creativity needs the guidance of leaders and teachers, whose innovative ideas are bound to stimulate students' desire for innovation.
- (4) Carry out the construction of university student associations. A class or university student association will have its own thought, style and code of conduct, which is the common spiritual wealth of the students. A good ethos will contribute to the physical and mental health of each member and facilitate the display of their creative potential.
- (5) Give full play to the leading role of campus' new media and create an online maker space. Students ought to be able to brainstorm in the online maker space at any time. All kinds of information could emerge here and breed new ideas and new concepts.

6 Conclusion

Based on the current situation of talent creativity development in China's applied undergraduates, this article summarises and analyses the factors affecting applied undergraduate creativity development through adequate research and investigation and literature knowledge-mining. The key factors of creativity development are found out based on principal component analysis (PCA), and the key factors influencing creativity development are analysed from two aspects of external factors and internal factors. Based on the analysis of the key factors, this article gives some suggestions on the development of students' creativity in universities with the objective of providing guidance and reference for teaching methods which can result in the development of students' creativity in universities, especially applied undergraduates.

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