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Design and Empirical Evidence of Teaching Resource Allocation Model and Reform Path

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Abstract: With the popularization of higher education, teaching quality has become an urgent problem to be solved. Aiming at the three difficulties faced by China's higher education at present: students' learning time after class is generally insufficient, about one-third of teachers still use the "monophonic broadcast" teaching method, and about two-thirds of teachers' teaching is not integrated enough with industrial practice, this paper puts forward an analytical model for the rational allocation of teaching resources in the direction of "textbook centered, teacher-centered and classroom-centered" and the other direction that "student-centered, student-learning-centered and learning-effect-centered", and points out that the main reason for the above three difficulties is the unreasonable allocation of teaching resources. In order to gradually realize the rational allocation of teaching resources, the author designed a gradual supporting reform path: that is, to improve the incentives for educational innovation, to allocate newly increased teaching and innovation resources in the direction of "learning effect as the center", to stabilize the traditional teacher group in the process of reform, to realize the continuous growth of the demand and output of teaching innovation through reform, and use the effective re-allocation of resources to guide and help teachers and students to migrate to the direction of "learning effect as the center". The above-mentioned supporting reforms have been implemented in Gengdan Institute, and good results have been achieved.

Keywords: Resource Allocation, Path Design, Reform in Education, Student-Centeredness

1. Introduction

According to the author's previous research [1], China's higher education is now facing three difficulties. First of all, university students' learning time after class is generally not enough. The ratio of extracurricular autonomous learning time of more than half of students to in class teacher's joint learning time is less than or equal to 0.5:1. However, according to the internationally accepted law of engineering and art teaching and learning, this ratio should be 1:1; and according to the law of business and liberal arts teaching and learning, this ratio should be 1.5:1. Secondly, 16%-38% of teachers still use the "monophonic broadcast" teaching method. Third, more than 60% of the teachers did not combine their teaching with the actual situation of the industry, and did not do enough on the real topic. This shows that the traditional knowledge inculcation system is still prevailing.

In 2021, China's higher education gross enrollment rate has increased to 57.8%, entering the stage of popularization [2], and teaching quality has become an urgent problem to be solved [3]. If we want to solve how each student learns? Learn what? How about the quality of learning? First of all, we need to solve how each teacher teaches. What to teach? This is actually a very difficult behavioral and institutional change problem.

In the early years, when studying the laws that should be followed in the transition of China's scientific and technological system, the author proposed a model for the allocation of limited resources between scientific and technological departments and economic departments. Through incremental resources driving stock resources adjustment, we can not only "open up one area" but also "stabilize one end", realize the effective re-allocation of resources between scientific and technological departments and economic departments, and the mutual promotion of science and technology and the economy [4, 5]. Later, this

model was applied by Zhang Wei and Ding Juan to study the industrial structure adjustment of China's investment [6] and technological leapfrogging [7]. Based on the above experience, the author puts forward a model to promote the transformation of behavior of teachers and students through the effective re-allocation of teaching resources, and has implemented progressive supporting teaching reform in some private universities in China. It can be briefly described as follows.

2. Teaching Resource Allocation Model

Assumptions: (1) a university can only invest teaching resources in the "Old Three Centers" direction and the "New Three Centers" direction. The former is "textbook centered, teacher-centered and classroom-centered", and its basic feature is that teachers teach textbooks in the classroom [8-10]. The latter is "student-centered, student-learning-centered and learning-effect-centered" [9-14], and its basic feature is the student-centered incentive growth paradigm [1]. (2) When the teaching resources of the university are used in the "Old Three Centers" direction, it is difficult to use them in the "New Three Centers" direction at the same time. In order to simplify the problem, the shared information resources are not considered for the time being, which does not affect the main conclusions drawn from the following analysis, because information resources always have to be combined with certain human and material resources to play a role. (3) It is further assumed that the proportion of teaching resources used for "Old Three Centers" direction and "New Three Centers" direction is relatively fixed. This is because in the process of institutional change, there exists the mechanism of self-reinforcing and increasing returns for vested interest groups. (4) If the resources used for teaching are fully allocated, that is, there is no efficiency loss of resource utilization, then there existed the possibility boundary OCD of teaching resource allocation determined by specific teaching resource endowment.

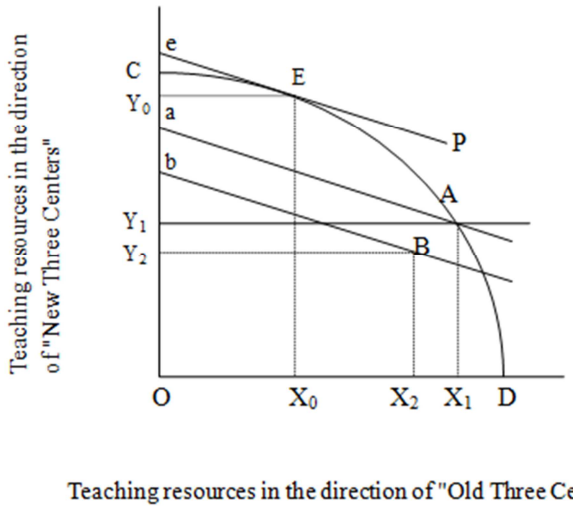

Figure 1. *Problems existing in the allocation of teaching resources in China.*

In Figure 1, EP represents a relative price line determined by the market. If there is no price distortion, the student-centered incentive growth paradigm has certain economic efficiency and talent growth inevitability, so it is necessary to allocate more teaching resources OY_0 in the direction of "New Three Centers" and less teaching resources OX_0 in the direction of "Old Three Centers". A relatively reasonable combination of resource allocation should be located in E.

Taking the highly competitive American higher education market as an example, the penetration rate of the "New Three Centers" is about 60%. Among them, the small, elite liberal arts colleges (mostly private) do best, with an 80-100% penetration rate. The second is the two-year and four-year teaching-type colleges (mostly public), the penetration rate can reach 50~70%. The third is the PhD-granting universities (mostly public) with a penetration rate of around 50%. The last is probably research universities (both public and private), with less than 50% penetration rate [9].

In China, due to the traditional knowledge inculcation and the planned economy inertia of the education system, the resources obtained in the "Old Three Centers" direction are expanded from OX_0 to OX_1. Meanwhile, the resources allocated in the "New Three Centers" direction are reduced from OY_0 to OY_1. At this time, the possible boundary of resource allocation is Y_1AD, and resource allocation portfolio is at point A instead of E in Figure 1. This is the main reason for the three difficulties in China's higher education.

As we can see in Figure 1, the static result of the above approach is: assuming that there is no price distortion, there is an absolute ea and relative ea/eo loss of talent training efficiency caused by improper allocation of teaching resources in the economy. This loss of efficiency will lead to the reduction of the surplus available for reinvestment in education. According to the previous assumptions, OX_1/OY_1 is relatively stable. On the one hand, the loss of talent training efficiency will further reduce the total investment available for education. On the other hand, each talent training cycle will repeatedly generate a loss of ea/eo. All these will seriously damage the mutual support and promotion between education and economic sectors (including ordinary citizens), resulting in low efficiency of talent training, low investment in education by enterprises and low contribution of education progress in economic growth.

Although China has been vigorously promoting the vocational and technical education, and combination of industry, education and research in recent years, however, due to the inadequate implementation of government incentives, enterprise incentives and market incentives for educational innovation in China, the fragmentation of education related government departments has further led to the ineffective combination of factors, the low efficiency of resource utilization, and the loss of talent training efficiency, so that the actual resource allocation combination is located at a certain point within the resource allocation possibility boundary, such as point B in Figure 1.

3. The Path Design of Gradual Reform in the Deep Water Area of Educational Reform

In view of the above unreasonable allocation of teaching resources, the author has designed a gradual supporting reform path as follows:

3.1. Improve the Incentives for Educational Innovation

First, strengthen the new combination of elements, implement the two-way temporary job system for not only sending teachers to the enterprise but also absorbing the engineering and technical personnel of the enterprise to the universities, promote the pilot system of modern industrial colleges and modern apprenticeships, establish a special budget management system related to tasks, and give micro-business units (such as secondary colleges, professional teaching and research offices) autonomy, improve incentives for education and scientific and technological innovation, mobilize the enthusiasm of vested interest groups (existing teacher groups, especially old teacher groups) to step out of their comfort zones, improve resource utilization efficiency, and make the resource allocation portfolio move from point B in Figure 1 to the possible boundary of resource allocation (near point A).

3.2. Allocate Newly Increased Teaching and Innovation Resources in the Direction of "New Three Centers"

Second, the reform of the micro-management mechanism enables the innovative subjects (teachers, leaders of secondary colleges etc.) with autonomy to allocate the newly created resources at their disposal in a more efficient and practical direction according to the market mechanism, including encouraging competent professional teachers to set up studios and lead students to run their own enterprises or cooperate with enterprises in new projects in accordance with the principle of "opening up one area". The dynamic changes in the allocation of newly increased teaching and innovation resources are from point A to point G in Figure 2A (The combination of teaching content and teaching method with production practice is more conducive to the realization of "student development as the center, student learning as the center, and learning effect as the center"), rather than in the direction of H point (traditional teaching content and teaching method). Note that this is the key for incremental resources to drive the adjustment of stock resources and overcome traditional path dependence.

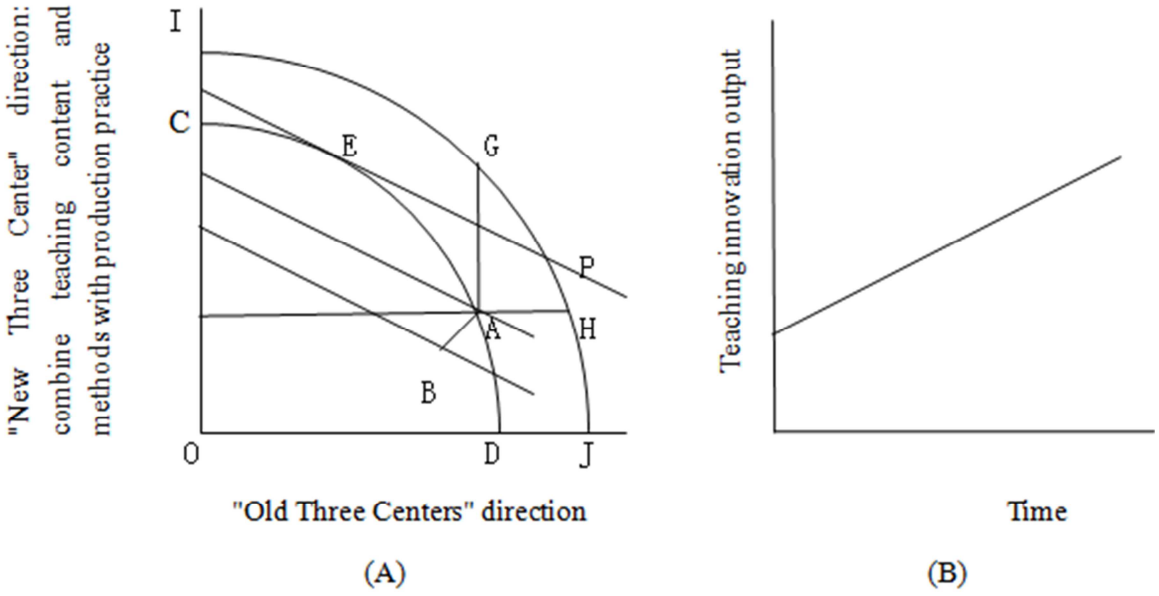

Figure 2. *Progressive reform path and corresponding teaching innovation output.*

3.3. Stabilize the Traditional Teacher Group in the Process of Reform

Third, as the traditional resource allocation system (such as the system of calculating workload by class hours for teachers) and the distorted macro policy environment are still maintained for a certain period of time, the university still allocates certain resources in the direction of "Old Three Centers", including continuing to support the traditional teacher group according to the principle of "stabilizing one end", so the allocation of newly increased resources according to the market mechanism will not cause the decline of the teaching output of the traditional teacher group.

3.4. Realize the Continuous Growth of the Demand and Output of Teaching Innovation Through Reform

Fourth, due to the introduction of the market competition mechanism and the implementation of the two-way temporary post system for both teachers and enterprise engineering technicians, the modern industrial college system, the pilot of

the modern apprenticeship system, studio courses and all-English teaching courses, students' sense of gain has increased, and the social demand for students has increased, the demand for teaching innovation increases (meaning that university resources are no longer only derived from tuition fees or higher-level grants, such as Stanford, Harvard and other famous universities, tuition fees only account for about 30% of the budget), the resources that can be used for teaching content and teaching method innovation increase, the possible boundary of resource allocation expands from OCD to OIJ, and the corresponding output of teaching innovation increases. Therefore, as shown in Figure 2B, during the process of reform, the efficiency of talent training, the output of teaching innovation will continue to grow. This growth will further drive economic growth and help to realize the positive interaction between education and economy.

3.5. Use the Effective Re-allocation of Resources to Guide and Help Teachers to Migrate Towards the "New Three Centers" Direction

Fifth, during this process, training camps for new teachers, teaching workshops at the beginning and the end of the semester, and special teaching competitions are continuously opened to train and motivate teachers to develop new teaching methods, teaching content reconstruction and new teaching evaluation methodology that are conducive to the "New Three Centers"; blocking new teachers from entering the "Old Three Centers" direction channel; at the same time, using the effective re-allocation of resources to guide and help traditional teachers to get out of the comfort zone, and actively to migrate to the direction of "new three centers" and to the direction of combining their teaching with production practice. When the number of teachers willing to reform exceeds 50% of the total number of teachers, the general trend of reform will be formed. Gradually complete the transition of most or all teachers to the new teaching content structure, new teaching method structure and new teaching evaluation structure.

3.6. Gradually Realize the Rational Allocation of Teaching Resources

Sixth, with the improvement of talent training efficiency and economic growth, new resources allocated in the direction of "New Three Centers" and the combination of teaching content with production practice are further increased, and the relative share of teaching resources allocated in the direction of "Old Three Centers" within the total resources is gradually reduced, step by step, reaching the reasonable allocation of teaching resources required by the change of relative product and factor prices under the condition of market economy.

4. Empirical Evidence

In the past few years, the author and colleagues have carried out gradual reform in Gengdan Institute of Beijing University of Technology (one of private university in China, hereinafter referred to as BGD) according to the above reform model, established a combined credit system [15], six closed-loop quality management systems for students, teachers, courses, majors (teaching and research offices, studios), secondary colleges and second-line management offices [16], cost-effective international education at home [1], and encouraged teachers to establish teaching studios in combination with their professional advantages. Good results have been achieved.

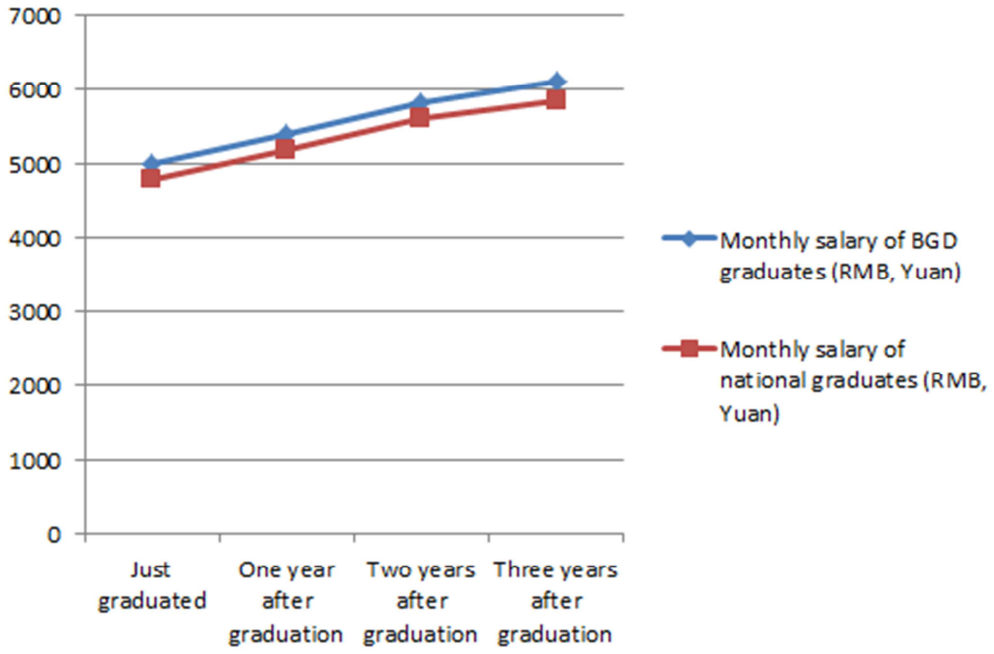

Figure 3. *Comparison of the average monthly salary of the 2014 BGD undergraduate graduates with that of national undergraduate graduates in the same year.*

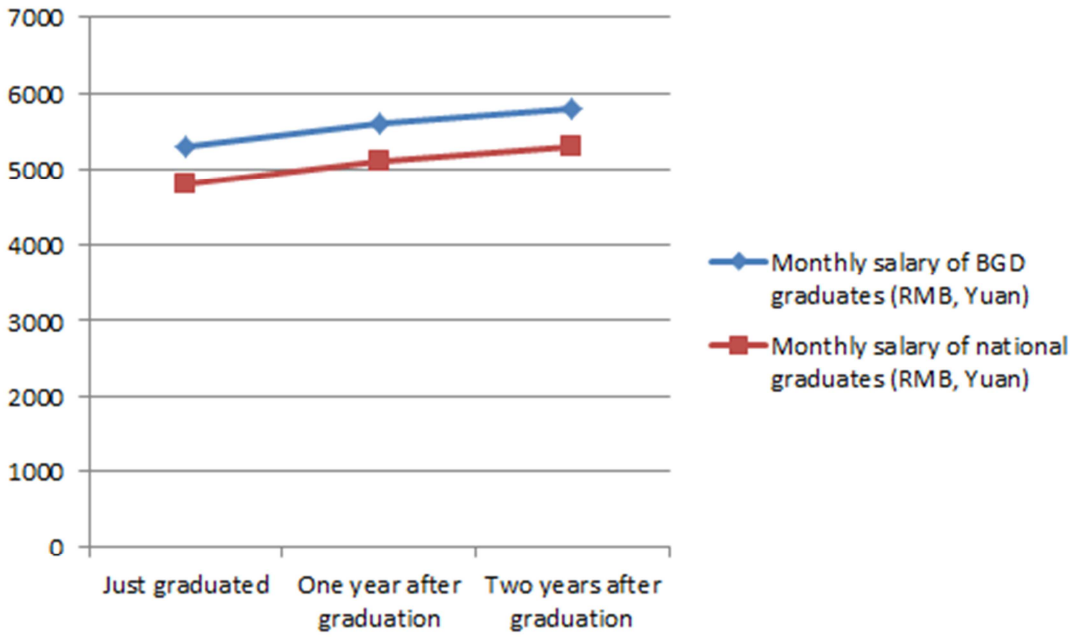

Figure 4. *Comparison of the average monthly salary of the 2015 BGD undergraduate graduates with that of national undergraduate graduates in the same year.*

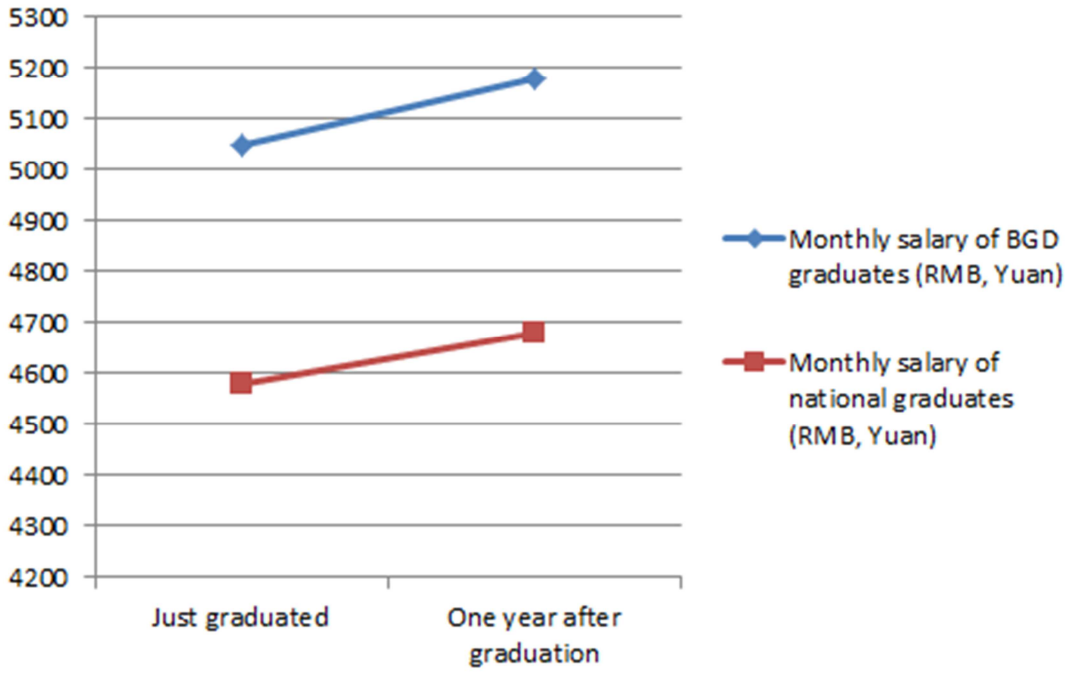

Figure 5. *Comparison of the average monthly salary of the 2016 BGD undergraduate graduates with that of national undergraduate graduates in the same year.*

Figures 3-5 shows the comparison between the average monthly salary of 2014, 2015 and 2016 BGD undergraduate graduates and the average monthly salary of national undergraduate graduates in the same year provided by Future Big Data (a third-party company). It can be seen that although the average score of BGD students is lower than the market average when they enter the University (Otherwise, they wouldn't have waited until the third batch to be admitted to university [1]), but the average salary of BGD students after graduation is higher than the market average. This is essentially the basic value of the existence of a university, which must add more value to the quality and ability of students.

1 Before 2020, Chinese universities admitted students in three batches based on their scores. Usually, students with the best scores are admitted by first-class universities in the first batch, students with above average scores are admitted by public universities in the second batch, and students with below average scores are admitted by private universities in the third batch.

Table 1. *Comparison of CEQ1 and CEQ2 in BGD.*

Semester	Number of courses taught in English (the same course name counts as one)	Total number of courses in a semester	Proportion in total courses	Number of participating teachers	CEQ1	CEQ2	CEQ1 is higher than CEQ2
15-16-2	0	367	0	0	0.00	0	0.00
16-17-1	34	395	8.60%	41	91.02	90.89	0.13
16-17-2	43	415	10.30%	48	91.56	90.75	0.81
17-18-1	68	486	13.90%	55	91.51	91.04	0.47
17-18-2	60	475	12.63%	58	92.29	91.26	1.03

Table 1 shows the implementation of all English Teaching in BGD since the 2016 academic year. It can be seen that the number of participating teachers is gradually increasing. The average score of classroom experience evaluation [17] (CEQ1) of all English teaching courses is higher than the average score of CEQ of whole university curriculum (CEQ2), and the difference between the two is gradually increasing. This shows that this teaching method has gradually been recognized by students and teachers. The after class survey also shows that because this teaching method has brought about the change of students' learning methods, students who participate in the all English teaching courses invest more time in after class learning than non-participants, and have a spillover effect. For example, the learning atmosphere of the 2017 grade software international class is significantly better than that of other classes in the Engineering College. Two students even won the first prize of the national and Beijing professional competitions merely in their freshman year.

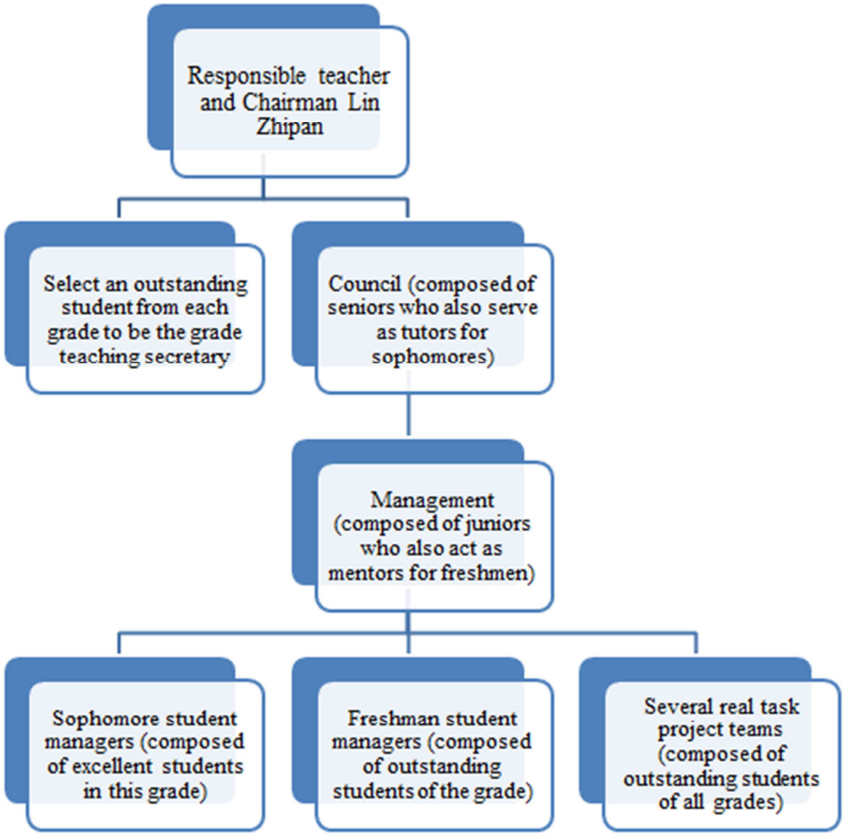

Figure 6. *Organizational structure of SHOWBIM situational teaching studio.*

Figure 6 shows the organizational structure of the SHOWBIM situational teaching studio founded by teacher Lin Zhipan and his students. Made up of a teacher and 111 students, the studio is a simulated corporate teaching place. It realizes the teaching that teacher leads students to do real projects; peer teaching that junior students teach freshmen, senior students teach sophomores; situational teaching that students learn not only knowledge but also professional ethics and self-management.

5. Conclusion

In many countries around the world, education is leading social and industrial development. But in China, has education led to social growth and industrial development? This is still a big question mark. Through the analysis of this paper, we can see that the main problem of Chinese education is that teaching resources are still mainly allocated

in the direction of the "Old Three Centers". If we want to allocate teaching resources in the direction of the "New Three Centers", we must change the habitual behavior of teachers and deepen the reform of teaching content, teaching methods and teaching evaluation. However, the teaching reform is very difficult. We need to take into account the behavior habits and vested interests of the existing teacher groups, carefully design and implement supporting reforms, and fully mobilize the enthusiasm of all parties. Only in this way can we gradually increase the efficiency of educational output through development.

Through the practice of the author and colleagues in BGD, it shows that we should adopt a gradual supporting reform path: that is, improve the incentives for educational innovation, allocate newly increased teaching and innovation resources in the direction of "New Three Centers", drive the adjustment of stock resources through the optimal allocation of incremental resources, stabilize the traditional teacher group during the process of reform, and realize the continuous growth of demand and output for teaching innovation through reform. By this way, we can guide the change of teaching behavior of teachers and the learning behavior of students, help teachers and students to realize the system transfer from the "Old Three Centers" to the "New Three Centers", and has achieved good results.

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