Mass Education or Elite Education- Optimal Decision Making for Curriculum Setting Based on Cost-Benefit Analysis

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Abstract-With the continuous development of science and technology in China and the gradual improvement of people's living quality, education has become an increasingly important topic of discussion. In recent years, many people have made efforts to make fundamental education available to more people. Meanwhile, many other people have also worked hard to enable talents to receive effective education. Previous studies focus on the differences between mass education and elite education and have explored education issues from different perspectives. However, there has been no effective integration of mass education and elite education.

In this thesis, the advantages and disadvantages of mass education curricula and elite education curricula are weighed and optimized based on cost-benefit analysis, and a mathematical model is used for analysis from the perspective of private higher education institutions. In the hypothetical case of this thesis, the number and type of curriculum, as well as the expenses and costs for curriculum development, are simulated to find an optimal balance between mass and elite education and to solve the problem of education costs and curriculum-related personalized services. Through model building and data simulating, this thesis finally provides the most cost-effective educational curriculum plan for private higher education institutions.

Keywords: mass education; elite education; cost-benefit; analysis and optimization

1. Introduction

1.1 Proposal of the Project

Education is a major issue affecting national welfare and the people's livelihood, and it is commonly believed that mass education and elite education are two major educational models. With the development of the times, the advantages and disadvantages of mass education and elite education are gradually revealed.

In ancient times, due to the limitation of productivity, the cost of studying, i.e., receiving an education, was extremely high, so elite education was prevailing at that time, and only the children of noble families had access to studying, while those from ordinary families did not have the opportunity to receive education at all. Elite education is mainly embodied in the private school system and mentoring system. The disadvantage of an elite education is that the cost is high, while its advantage is reflected in the quality of education. Owing to its strong

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pertinence, customizable training programs, and other reasons, elite education can generate good results and deliver high education quality.

Mass education originates from modern times and is mainly embodied in modern primary and secondary schools. Due to the increase in productivity level, most people have access to education, and meanwhile, the cost of schooling for each individual is significantly lower. Low cost and high accessibility are the main advantages of mass education, while its disadvantage is that the knowledge taught is fundamental. As a result, this form of education has relatively low pertinence. Elite education, recognized standards of higher education: school-age population enrollment rate which is less than 15%, is called elite education while the enrollment rate between 15% and 45% is called mass education.

In this day and age, the development of society demands more from education. It is necessary not only to provide access to education for a large population but also to keep the cost of education relatively low and teach students according to their abilities. Neither mass education nor elite education can meet the needs of society alone, and this becomes evident in everyday life.

The popularization of higher education is one of the trends and characteristics of higher education development in the world today, and China is also moving towards the popularization of higher education. It is expected that everyone will have access to education and the opportunity to receive high-quality education. To this end, it is necessary to explore the balance between elite and mass education and combine the strengths of both to provide the highest quality education possible while controlling the cost of education.

1.2 Current Status of Related Studies

For the above purposes, not a few scholars have conducted in-depth and meaningful studies on such issues as mass education, education equalization, elite education, individualized education, education costs, and education benefits [1] [2]. Scholar Wang [3] has studied liberal education with mass education as the aim and has broken the previous restriction that certain knowledge is only for professional students or people. Scholars Wang and Tang [4] believe that education should not only follow the general rules of educating people and the requirements of commonality development but also respect the personalized needs of different individuals. Gou [5] has analyzed the short-term benefits of higher education in terms of the growth of higher education consumption, the promotion of the development of related industries, and the boosting of overall economic growth, and has also elaborated on the long-term benefits of higher education from the perspective that the higher education is regarded as a part of social production. Finally, it is concluded that the healthy and stable development of higher education can contribute to the construction of China’s economy. Tian [6] has explored the application of value chain-related theories in the cost accounting and management of higher education institutions and provided a novel concept for the education cost accounting of China’s colleges and universities, aiming to obtain more accurate and comprehensive information on the education costs of colleges and universities. Bai and Meng [7] have pointed out that individualized education is an education form that focuses on developing students’ personalities based on respecting their differences. For example, teachers fully consider the students’ way of thinking, intellectual level, and learning habits and take the development of students as the center, and education revolves around the needs of students’ development[9,10].

1.3 Purpose of the Study

The above-mentioned studies have explored education issues from different perspectives but failed to effectively integrate mass and elite education in the higher education sector. For the integrated development of mass education and elite education, private higher education institutions and higher vocational colleges are a force to be reckoned with in terms of the growth pattern of higher education. China has a history of more than 30 years of developing private higher education institutions. The number of school students has exceeded 5.57 million. Meanwhile, private higher education institutions are no longer in the state of "three nos" (no capital, no teachers, and no school buildings) as they were 10 or 20 years ago. Instead, they pay more attention to constructing campus culture and improving education quality. Compared with public colleges and universities, private higher education institutions attach more importance to their characteristics and respect for students' interests and hobbies. The flourishing of private higher education institutions can help to share the task of popularizing higher education and relieve the pressure of elite universities. In addition, different evaluation mechanisms and classification management are implemented for various private higher education institutions. This will also create more talents mastering high-grade, precision, and advanced technologies.

Therefore, this thesis will weigh and optimize the advantages and disadvantages of mass education curriculum and elite education curriculum from the perspective of private higher education institutions based on cost-benefit analysis, and maximize the profits of private higher education institutions by distributing different ratios for mass education and elite education curriculum under the premise that students' educational needs are fully satisfied so that colleges and universities can obtain continuous financial support and motivation for further curriculum development, iteration, and upgrading. The good profitability of private higher education institutions can also provide strong support for subsequent expansion and standardized management, allowing them to offer better educational resources for more students and become a powerful complement to the public education system[8].

2. Research Methods

2.1 Principal Introduction

0-1 programming is a special type of integer programming in which the decision variables are restricted to 0 or 1. That is, the decision variables can only be 0 or 1. 0-1 programming is a special form of Integer programming. 0-1 variables can quantitatively describe binary logical relationships, sequential relationships, and mutually exclusive constraint conditions condition among discrete variables variable, which are reflected in such phenomena as on and off, taking and discarding, with or without, etc. Therefore, 0-1 programming is well suited to describe and solve a variety of problems that people care about, such as route design, plant location, production planning and scheduling, travel shopping, knapsack problem, staffing, code selection, reliability, etc. Any integer programming with bounded variables programming can be handled by converting it into 0-1 programming. Because of its profound background and widespread application, 0-1 programming has been valued for decades. 0-1 programming is mainly used to solve mutually exclusive programming problems, mutually exclusive constraint conditions, fixed-charge problems, assignment problems, etc.

The model for 0-1 programming can be expressed as follows:

$$\max \quad z = \sum_{j=1}^{n} c_j x_j$$

$$s.t. \quad \sum_{j=1}^{n} a_j x_j \leq B$$

$$x_j = 0{,}1.$$

2.2 Model Building

Objective function = charge function - cost function

Variables:

i: Course type

α_i: The difficulty level of course offering (the charge standard raises as the difficulty level, of course, offering increases, 1≤α_i≤10)

M_i: Course capacity (the lower the course capacity is, the higher the charge standard will be)

β_i: Degree of freedom to choose courses (the higher the freedom degree is, the higher the charge standard will be 0≤β_i≤1)

θ_{ij}: Similarity of courses in a course package (after course packages are substituted for each other, the development cost will be reduced, and the charge will be lowered as well, 0≤θ_{ij}≤1)

C_i: Ideal price for course package$i$

Wherein, C_i=$\alpha_i * 1000*\ \beta_i$.

The charge function is:

$$\sum_{i=1}^{n} C_i * M_i \tag{1}$$

$$\text{i.e., } \sum_{i=1}^{n} \alpha i * \beta_i * 1000 * M_i. \tag{2}$$

Concerning cost, this thesis mainly considers fixed cost, quasi-fixed cost, and variable cost the three parts.

1) Fixed cost: For example, the rent of teaching buildings, and its value is set to U

2) Quasi-fixed cost: The cost of developing a course, if no course is developed, the cost will be 0.

The development cost for the course package i is set to D_i.

$$\delta_i \begin{cases} 1 & \text{develop No.}\, i \text{ course} \\ 0 & do\ not\ develop\ No.\, i \text{ course} \end{cases} \tag{3}$$

The total quasi-fixed costs $D_t$is:

$$D_t = \sum_{i=1}^{n} D_i * \delta_i. \tag{4}$$

3) Variable cost: It is generally believed that the variable cost is proportional to the number of students.

It's assumed that the cost per student is C_s.

The total variable cost is C_t:

$$C_t = C_s \sum_{i=1}^{n} M_i. \tag{5}$$

Then the objective function is the total profit P_t:

$$P_t = \sum_{i=1}^{n} C_i * M_i - U - \sum_{i=1}^{n} D_i * \delta_i - C_s \sum_{i=1}^{n} M_i. \tag{6}$$

While different types of students require different courses, there is a similarity among different courses. The lower the similarity is, the higher the degree of personalization of a course is. It is also assumed that when a course x with a similarity of $\theta$is used to substitute other courses, the course cost is also multiplied by θ.

Then the new objective function is the total profit P_t:

$$P_t = \sum_{i=1}^{n} C_i * \theta i_{max} * M_i - U - \sum_{i=1}^{n} D_i * \delta_i - C_s \sum_{i=1}^{n} M_i. \tag{7}$$

3. Experimental Procedure and Results

3.1 Study Instance One

It's assumed that the variables of the instance are as shown in Table 1.

i=5 (a total of 5-course packages are set.)

$\alpha_1 = 1$; $\alpha_2 = 3$; $\alpha_3 = \alpha_4 = 4$; $\alpha_5 = 5$

$M_1 = 50$; $M_2 = 30$; $M_3 = 25; M_4 = 10; M_5 = 5;$

$\beta 1 = \beta 2 = \beta 3 = 0.5; \beta 4 = 0.8$; $\beta 5 = 0.9.$

Table 1 Similarity among Courses θ (obtained based on actual research)

Substitution rate θ	Course 1	Course 2	Course 3	Course 4	Course 5
Course 1	100%	90%	88%	91%	71%
Course 2	90%	100%	79%	95%	90%
Course 3	88%	79%	100%	84%	85%
Course 4	91%	95%	84%	100%	70%
Course 5	71%	90%	85%	70%	100%

According to $C_i=\alpha_i * 1000* \beta_i$:

It can be concluded that C1=500; C2=1, 500; C3=2, 000; C4=3, 200; C5=4, 500; (charging standard for each course package)

W1=25, 000 W2=45, 000 W3=50, 000 W4=32, 000 W5=22, 000

U=10, 000 (fixed cost)

D1=5,000 D2=6,000 D3=7,500 D4=D5=10,000 (development cost for each course package)

Cs=100 (variable cost per student)

The experiment with course combinations and schedules can be conducted after assumptions are made:

First scheme: All five-course packages need to be developed

Total profit = 113, 500

Subsequent schemes are as shown in Table 2: some course packages do not need to be developed, while others need to be developed.

Table 2 Simulated Course Schedule Table

Scheme number	Selected course number	Total course profit
1	1, 2, 3, 4, 5	113, 500
2	1	127, 240
3	1, 2	127, 020
4	1, 2, 3	129, 700
5	1, 2, 3, 4	121, 300
6	2, 3	132, 200
7	2, 4	123, 550
8	2, 5	124, 400
9	1, 3	128, 820
10	1, 4	120, 370
11	1, 5	123, 620
12	3, 4	126, 700
13	3, 5	121, 880
14	4, 5	120, 000
15	1, 3, 4	122, 800
16	2, 3, 4	124, 050
17	1, 4, 5	118, 750
18	1, 2, 4	127, 800
19	1, 2, 5	123, 400
20	1, 3, 5	122, 120
21	2, 3, 5	124, 400
22	3, 4, 5	120, 000
23	1, 2, 3, 5	121, 900
24	1, 2, 4, 5	11, 500
25	2, 3, 4, 5	116, 250

This result implies that in this experiment, the curriculum design of scheme 6 can generate the most profit, which indicates that offering a combination of courses 2 and 3 which is more mass education-oriented can gain a maximum profit of RMB 132, 200.

3.2 Study Instance Two

From instance one, I learned that Excel could produce accurate calculation results and optimal solutions by exhaustive enumeration when there are only a few types of courses as shown in Table 3. However, once the number, of course, types rise to 10 or even 15, the calculation volume will increase exponentially, and Excel will be unable to meet such calculation demand.

Therefore, I taught myself the MATLAB software and put forward the hypothesis of instance two:

i =10 (a total of 10-course packages are set, and among them, i1 to 5 are set as mass education courses, while i 6 to 10 are set as elite education courses)

$\alpha1 = 1$; $\alpha2 = 3$; $\alpha3 = \alpha4 = 4$; $\alpha5 = 5$; $\alpha6 = 6; \alpha7 = 7; \alpha8 = \alpha9 = 8; \alpha10 = 10$

$M_1 = 50$; $M2 = 30$; $M3 = 25; M4 = 10; M5 = 5; M6 = M7 = 3; M8 = M9 = 2; M10 = 1$

$\beta1 = \beta2 = \beta3 = 0.3; \beta4 = 0.5$; $\beta5 = 0.7$; $\beta6 = \beta7 = \beta8 = 0.8; \beta9 = 0.9; \beta10 = 1$

It is assumed that $Ci = 2000 * \alpha i * \beta i$.

C1=600 C2=1, 800 C3=2, 400 C4=4, 000 C5=7, 000 C6=9, 600 C7=11, 200 C8=12, 800 C9=14, 400 C10=20, 000

U=10, 000 (fixed cost)

D1=10, 000 D2=11, 000 D3=11, 500 D4=D5=12, 000 D6=D7=15, 000 D8=D9=17, 500 D10=18, 000 (development cost for each course)

Cs=100 (variable cost per student)

Table 3 Substitution Rate among Coursesθ

Substitution rate θ	Course 1	Course 2	Course 3	Course 4	Course 5	Course 6	Course 7	Course 8	Course 9	Course 10
Course 1	100%	90%	88%	91%	71%	75%	67%	57%	50%	45%
Course 2	90%	100%	79%	95%	90%	84%	74%	64%	67%	78%
Course 3	88%	79%	100%	84%	85%	77%	83%	77%	77%	65%
Course 4	91%	95%	84%	100%	70%	82%	74%	79%	69%	73%
Course 5	71%	90%	85%	70%	100%	96%	85%	67%	80%	82%
Course 6	75%	84%	77%	82%	96%	100%	92%	88%	86%	77%
Course 7	67%	74%	83%	74%	85%	92%	100%	97%	95%	90%
Course 8	57%	64%	77%	79%	67%	88%	97%	100%	98%	92%
Course 9	50%	67%	77%	69%	80%	86%	95%	98%	100%	98%
Course 10	45%	78%	65%	73%	82%	77%	90%	92%	98%	100%

Below is the model-building and solving process of the above instance with MATLAB

MATLAB has provided the function intlinprog to solve the 0-1 0-10-1 programming problem as shown in Figure 1.

```
a=[1 3 4 4 5 6 7 8 8 10];
M=[50 30 25 10 5 3 3 2 2 1];
b=[0.3 0.3 0.3 0.5 0.7 0.8 0.8 0.8 0.9 1];
D=[10000 11000 11500 12000 12000 15000 15000 17500 17500 18000];
U=10000;
CS=131*100;
for i=1:10
    C(i)=a(i)*b(i)*2000;
    T(i)=C(i)*M(i);
end
f1=T*theta-D;
f=f1*(-1);
A0=[1 1 1 1 1 1 1 1 1 1];
b=[5];
intcon=[1 2 3 4 5 6 7 8 9 10];
lb = zeros(10,1);
ub = ones(10,1);
[x,fval]=intlinprog(f,intcon,A,b,[],[],lb,ub);
```

Figure 1. Model-building and Solving Process with MATLAB

Wherein, the coefficient matrix is shown in the figure 2 below.

10x10 double

	1	2	3	4	5	6	7	8	9	10	11
1	1	0.9000	0.8800	0.9100	0.7100	0.7500	0.6700	0.5700	0.5000	0.4500	
2	0.9000	1	0.7900	0.9500	0.9000	0.8400	0.7400	0.6400	0.6700	0.7800	
3	0.8800	0.7900	1	0.8400	0.8500	0.7700	0.8300	0.7700	0.7700	0.6500	
4	0.9100	0.9500	0.8400	1	0.7000	0.8300	0.7400	0.7900	0.6900	0.7300	
5	0.7100	0.9000	0.8500	0.7000	1	0.9600	0.8500	0.6700	0.8000	0.8200	
6	0.7500	0.8400	0.7700	0.8200	0.9600	1	0.9200	0.8800	0.8600	0.7700	
7	0.6700	0.7400	0.8300	0.7400	0.8500	0.9200	1	0.9700	0.9500	0.9000	
8	0.5700	0.6400	0.7700	0.7900	0.6700	0.8800	0.9700	1	0.9800	0.9200	
9	0.5000	0.6700	0.7700	0.6900	0.8000	0.8600	0.9500	0.9800	1	0.9800	
10	0.4500	0.7800	0.6500	0.7300	0.8200	0.7700	0.9000	0.9200	0.9800	1	
11											

Figure 2. Coefficient Matrix

The solving process is shown in the figure 3 below.

```
LP:                Optimal objective value is -2.769932e+06.


Optimal solution found.

Intlinprog stopped at the root node because the
objective value is within a gap tolerance of the optimal value,
options.AbsoluteGapTolerance = 0 (the default value). The intcon variables are
integer within tolerance, options.IntegerTolerance = 1e-05 (the default value).
```

Figure 3. Solving Process

The result is shown in the figure 4 below.

```
x =

     0
     1
     0
     0
     1
     0
     1
     0
     1
     0

>> -fval

ans =

     2769932
```

Figure 4. Results

This result implies that in this instance, offering mass education courses 1 and 5 as well as personalized courses 7 and 9 can generate a maximum profit of RMB 2, 769, 932. Educational institutions can use such funds for the development of new courses or the iteration and upgrading of old courses. It also provides the possibility to continue to expand and bring in senior educational talents in the future.

3.3 Instance Study Summary

In this chapter, by using a mathematical model and based on reasonable assumptions, a series of data such as course type, curriculum setting fund, similarity rate of courses, student capacity of courses, and selection rate of courses are listed, and the optimal solution of curriculum setting is finally arrived at through calculation. Although there are many interference factors in real life, this model can still help private higher education institutions find the most favorable balance between mass education curriculum and elite education curriculum to the maximum extent possible.

4. Analysis and Discussion

Based on instance studies, this thesis adopts a mathematical model and computer simulation experiment to perform data simulation and model solving, to validate and optimize algorithms.

The study instances have simulated the number of course types, and the setup of each type of course, including course development cost and the cost of each set of courses, as well as fixed costs. Based on this, it’s concluded that:

Firstly, through data simulation and substitution rates, the best possible curriculum setting, and arrangement can be calculated in certain circumstances.

Secondly, the curriculum setting allows private higher education institutions to obtain the maximum financial return while realizing certain educational effects.

5. Conclusions

In the context of the current era, people not only demand greater access to education but also pursue high-quality education. This is because society has put forward higher requirements for talent cultivation. But in fact, education requires high levels of resources and is very resource intensive. Therefore, this thesis aims to conduct trade-offs and optimization for private higher education institutions in terms of individualized cultivation, costs, and benefits, to enable educated people to get a high-quality education, while also enabling private higher education institutions to obtain optimal profits, thus promoting the balanced development of elite education and mass education. The model proposed in this thesis aims to solve the problem of education costs and curriculum-related personalized services. According to the calculation results in this thesis, it is found that the optimal solution is neither to provide a completely personalized product or service for all students nor to offer a uniform product or service for all students. Instead, it is to find a most balanced state based on considering the educational needs of students and a series of cost and revenue analyses, to fully satisfy educational effects and enable private higher education institutions to realize optimal profits.

The limitations of this study include the following: Firstly, the differences between students' learning levels are not considered. Secondly, this thesis fails to sufficiently consider the correlation between the quality of grading and the price of courses, which may affect the costs and profits of private higher education institutions.

Reflection and acknowledgment:

Inspirations come from daily accumulations. I got the inspiration for this thesis on my way home after a one-on-one course. More than once after completing the one-on-one course, I wondered why I was learning more effectively in this mode of learning and why we couldn't change all of our daily classes to the one-on-one mode. Later, after discussing this issue with many of my friends, I realized that the main reason was cost. The cost is certainly proportional to the quality of education, and the school curriculum and the one-on-one teaching are just two extremes. It was the first time I had the initial idea of mass education and elite education, and then I started to think if we could find a balance between the two models. That's what causes me to do this study and this thesis.

Driven by curiosity, I learned how to use Excel and MATLAB software, and consulted education-related literature. Meanwhile, I used mathematical models and hypothetical values to calculate the final benefits that different types, of course, combinations can bring to education providers. I have encountered many technical and knowledge problems, and I am thankful to my classmates for their help during this course, and grateful to my teachers for helping me solve technical and ideological problems and analyzing them together with me, which eventually enabled me to complete this thesis successfully.

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