IE407 - Fundamentals of Operational Research
Term Project - Selecting Corporate Training Programs
Group-17

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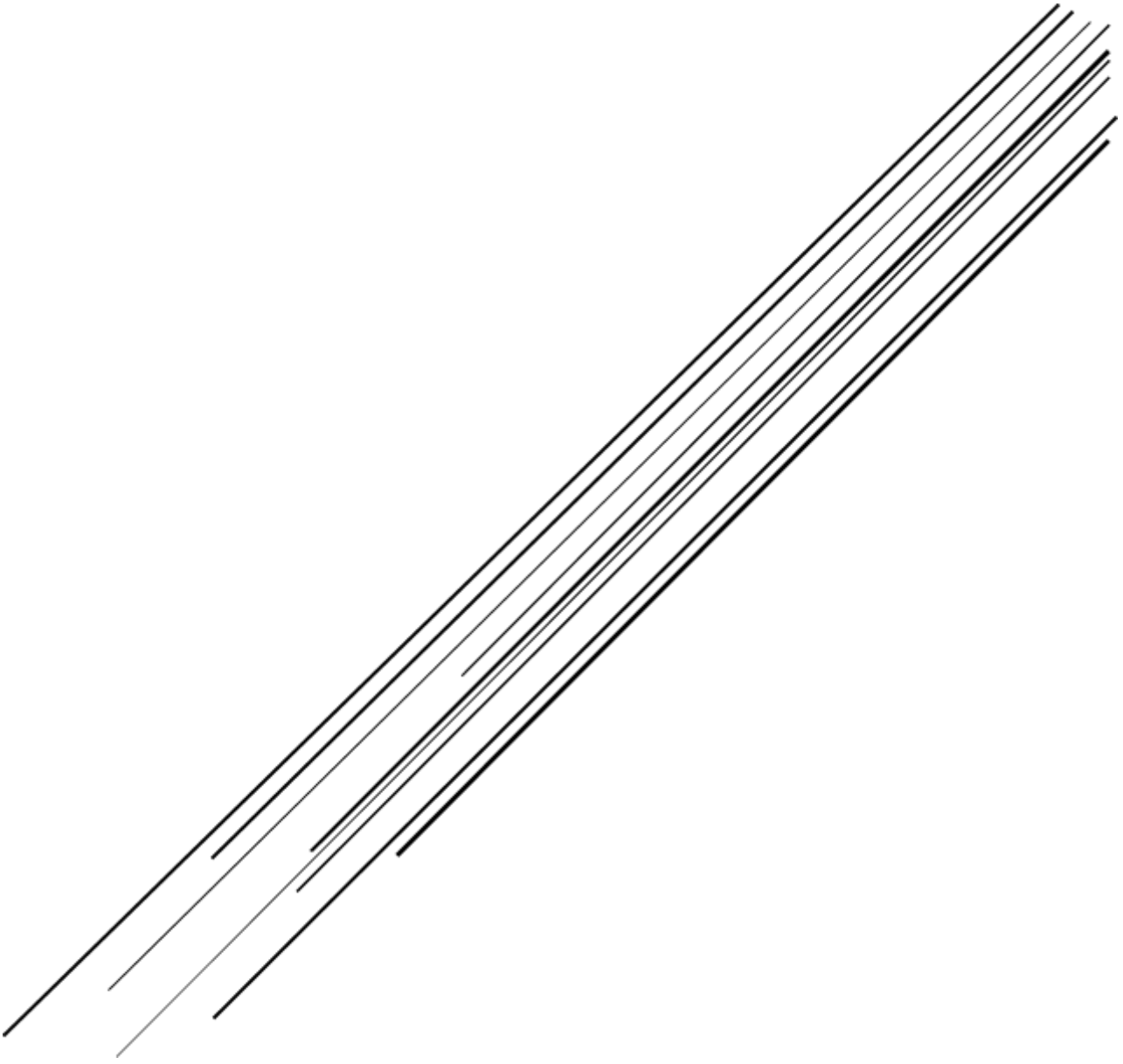

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1. Introduction

We have conducted a study to design corporate training program assignments to the employees of a small company. Our task was to determine optimal design for the assignment of training programs to employees for next year.

Our company has 13 employees in total with 6 different titles. The distribution of the employees according to their titles are as follows: 1 senior manager, 2 project managers, 3 professionals, 2 salesperson, 3 technicians and 2 administrative assistants. Company listed 41 skills for its employees and skill requirements for each title. There are 15 programs that company can provide their employees to cover their skills requirements and each of these programs contribute to several various skills. Programs are not provided as in-house classes in the company instead vendors of the programs provide all training process for the employees. We have a couple of properties related to training programs. First, programs have their registration costs (in Turkish Liras) which are to be paid by our company per assignment; secondly, we have a duration (in days) per program which makes assigned employees unable to work, namely not present in the company office during the whole duration of the program. Out of 15 training programs we have 6 programs that have overlapping schedule with each other during the whole year. For the employees that are to be assigned to these training programs we have the following restrictions: Each employee can be away for the training programs at most for 17 days and at least 1 employee with Professional title and 1 employee with Technician title must be available at the company at any time during the whole year to make sure operations of company keeps going.

Now here we are asked to create an assignment design of programs to the employees that yields minimum cost in total for our small company. There are 4 main restrictions that we must obey to create a bounded and feasible region for our optimal solution:

- We need to cover all skill requirements for the employees using various training programs.
- We need to make sure that, at a time t there is at least 1 Professional and 1 Technician in the Company.
- We need to make sure that all employees are assigned to the training programs so that they spent at most 17 days away from the company.
- We need to make sure that an employee can not be assigned both of the overlapping programs at the same time.

By using these information that includes our objective and restrictions, we are going to construct a model that best fits our needs and yields us the best decisions to acquire optimal cost for the company in our feasible region.

2. Main Body of the Report

2.1. Initial Plan

We needed to aid businesses and corporations in determining the appropriate training programs to use therefore we decided to approach the problem using an Integer Programming model with one decision variable since problem contains key decisions based on assignment of resources. Firstly we have categorized this problem as a minimization problem then we have determined our objective statement which is minimizing the cost of the assignment of corporate training programs to the employees. Then we have constructed our binary decision variable which implies binary decisions on the assignment. Using this decision variable, we have then created our objective function which is purely based on the costs of employee versus program assignments. Then using given description of the problem we have determined several constraints that limits our feasible region.

2.2 Assumptions

We enumerated employees according to the given title description and assumed that their mapping with enumeration is as follows:

- Employee-1 is the Senior Manager,
- Employee-2 is a Project Manager, Employee-3 is the other Project Manager,
- Employee-4 is a Professional, Employee-5 is the other Professional, Employee-6 is another Professional,
- Employee-7 is a Salesperson, Employee-8 is the ther Salesperson,
- Employee-9 is a Technician, Employee-10 is the other Technician, Employee-11 is another Technician,
- Employee-12 is an Administrative Assistant and Employee-13 is the other Administrative Assistant.

On the other hand we have assumed that except the conflicting training programs, none of the other training programs overlaps with each other during their duration.

Also we have assumed that the given costs of the training programs contain all the other expenses related with vendor-provided programs such as transportation and accommodation etc. as well as the real cost of the training program.

Lastly, for question C, we have assumed that the negotiation results with same percent discount in the cost of the program, not the same amount of money discount in the cost of the program.

2.3. Model

2.3.1. Objective

Minimize the cost of the assignment of corporate training programs to the employees.

2.3.2. Decision Variables

$$X_{ep} = \begin{cases} 1, & \text{if Employee } e \text{ is assigned to Program } p \\ 0, & \text{otherwise} \end{cases}$$

While generating the decision variables, we used two different indices. p represents training programs and e represents employees.

$$p \in P \text{ where } P = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15\}$$
$$e \in E \text{ where } E = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13\}$$

2.3.3. Objective Function

$$Min \sum_{p=1}^{15} \sum_{e=1}^{13} X_{ep} \times C_p$$

Where C_p represents the cost of taking program p.

2.3.4. Constraints

2.3.4.1 Day (Time) Constraint

$$\sum_{p=1}^{15} X_{ep} \times D_p \leq 17 \quad \text{For each } e \in \{1, 2, ..., 13\}$$

Where D_p is the day spent while taking program p

2.3.4.2. Conflicting Programs Constraints

$$X_{e1} + X_{e3} \leq 1 \quad \text{For each } e \in \{1, 2, ..., 13\}$$
$$X_{e9} + X_{e15} \leq 1 \quad \text{For each } e \in \{1, 2, ..., 13\}$$
$$X_{e11} + X_{e12} \leq 1 \quad \text{For each } e \in \{1, 2, ..., 13\}$$

2.3.4.3. Being Present in the Office Constraints

- For Professionals

$$\sum_{i=4}^{6} X_{i1} + \sum_{i=4}^{6} X_{i3} \leq 2, \quad \sum_{i=4}^{6} X_{i9} + \sum_{i=4}^{6} X_{i15} \leq 2, \quad \sum_{i=4}^{6} X_{i11} + \sum_{i=4}^{6} X_{i12} \leq 2,$$
$$\sum_{i=4}^{6} X_{i2} \leq 2, \quad \sum_{i=4}^{6} X_{i4} \leq 2, \quad \sum_{i=4}^{6} X_{i5} \leq 2, \quad \sum_{i=4}^{6} X_{i6} \leq 2, \quad \sum_{i=4}^{6} X_{i7} \leq 2,$$
$$\sum_{i=4}^{6} X_{i8} \leq 2, \quad \sum_{i=4}^{6} X_{i10} \leq 2, \quad \sum_{i=4}^{6} X_{i13} \leq 2, \quad \sum_{i=4}^{6} X_{i14} \leq 2$$

- For Technicians

$$\sum_{i=9}^{11} X_{i1} + \sum_{i=9}^{11} X_{i3} \leq 2, \quad \sum_{i=9}^{11} X_{i9} + \sum_{i=9}^{11} X_{i15} \leq 2, \quad \sum_{i=9}^{11} X_{i11} + \sum_{i=9}^{11} X_{i12} \leq 2,$$
$$\sum_{i=9}^{11} X_{i2} \leq 2, \quad \sum_{i=9}^{11} X_{i4} \leq 2, \quad \sum_{i=9}^{11} X_{i5} \leq 2, \quad \sum_{i=9}^{11} X_{i6} \leq 2, \quad \sum_{i=9}^{11} X_{i7} \leq 2,$$
$$\sum_{i=9}^{11} X_{i8} \leq 2, \quad \sum_{i=9}^{11} X_{i10} \leq 2, \quad \sum_{i=9}^{11} X_{i13} \leq 2, \quad \sum_{i=9}^{11} X_{i14} \leq 2$$

2.3.4.4. Employees' Skill Coverage Constraint

$$\sum_{p=1}^{15} \sum_{e=1}^{13} X_{ep} \times Y_{ps} \geq \sum_{e=1}^{13} Z_{es} \quad \text{For each skill } s \in \{1, ..., 41\}$$

Where Y_{ps} represents whether Program p covers skill s or not; and Z_{es} represents whether Employee e needs to have skill s or not.

2.4. Findings

Day, conflicting program and being present in office constraints are created by using the above mathematical expressions as well as given tables. However, in order to deal with employee skill coverage constraint, it is required to multiply decision variables table and Program vs Skill table and put the result in the Employee's Skill Coverage matrix(table 1 in appendix). This matrix is expected to be equal or greater than Employee vs Skill table(table 2 in appendix). Hence, this situation constitutes another constraint on developed model.

When constructed model is executed by open solver with respect to the given criteria and constraints, decision variable results for minimum cost are found. Obtained employee-program assignments can be seen in the appendix, table 3. Since optimized values are found for this model, analysis and discussions about findings can be applied.

2.4.1 Answers to Questions

For part a, assignment of employees to programs can be seen from table 3 in the appendix, which exactly shows our model's decision variables. As explained in the section 2.3.2, our decision variables indicates whether an employee E is assigned to a program P or not. Except programs 3 and 12, all programs will be used by the company's employees. Total cost of these assignments is in the objective function cell, which is 29775 Turkish Liras.

For part b, total usage of programs and total cost of the programs can be seen from table 4 in the appendix. As can be understood from this table, the most heavily used program is program 10 with 10 usages and program 9 is the second program after program 10 with 6 usages. We have additional expenses such as transportation and accommodation per the employee that is taking these courses in addition to the real cost of the program. Hence the company can develop an in-house course for program 10 instead of providing it from the vendor and can get rid of additional expenses at least for the most heavily used program, namely for program 10. In this way, company can spend all the money spent on program 10 on the development of an in-house course for program 10 which is 5000 Turkish Liras.

For part c, the logical selection of programs for negotiation should be based on total cost of the programs. For example, if selected course number for negotiation is 3, by consulting the table 4 in the appendix, it can be seen that top 3 costly programs are program 10 with 5000 Turkish Liras, program 11 with 3500 Turkish Liras and program 4 with 2875 Turkish Liras.(as we mentioned in assumptions section, we have assumed that the discount is based on percentage rather than amount of money).

For part d, table 5 is created for skills and its cost to cover it. This table can be found in appendix. If company is decided to develop its own programs, it will be more profitable that cover the most costly skills in these programs. As can be seen from table, top 5 most expensive skills are 38, 35, 2, 41, 25. Thus, if the intended program will cover 5 skills, these skills should be covered.

3. Conclusion and Recommendations

By constructing a model, we have managed to obtain the optimized decision variable values for assignment problem with satisfying given criteria and constraints. We have achieved the minimum cost value which is 29775. By analyzing the acquired tables from the model, we have discussed about heavily used courses, most expensive courses and most expensive skills. In addition to that, developing an in house course necessity and deciding programs to negotiation with vendor are argued.

5. Appendix

For tables 1,2 and 3, rows are(respectively):

E1-Senior Manager
E2-Project Manager
E3-Project Manager
E4-Professional
E5-Professional
E6-Professional
E7-Sales person
E8-Sales person
E9-Technician
E10-Technician
E11-Technician
E12-Administrative Assistant
E13-Administrative Assistant.

Table 1:Employee's Skill Coverage

Skill 1	Skill 2	Skill 3	Skill 4	Skill 5	Skill 6	Skill 7	Skill 8	Skill 9	Skill 10	Skill 11	Skill 12	Skill 13	Skill 14
2	1	1	2	1	1	0	0	0	1	0	3	1	1
0	1	0	2	1	1	1	1	1	1	1	3	3	1
0	1	0	2	1	1	1	1	1	1	1	3	3	1
1	2	1	3	1	1	1	2	2	2	0	2	1	1
2	1	0	2	2	2	1	2	1	0	1	3	2	1
2	2	2	2	2	1	1	1	1	2	1	3	4	1
1	2	1	3	0	0	0	1	2	2	0	2	1	1
1	2	1	3	0	0	0	1	2	2	0	2	1	1
2	1	1	1	3	2	2	2	1	0	1	1	2	1
1	1	2	1	2	1	1	1	1	1	0	0	2	0
1	1	1	2	1	1	0	1	1	1	0	1	1	0
1	1	1	2	1	1	0	0	0	0	0	1	1	1
1	1	1	2	1	1	0	0	0	0	0	1	1	1

Skill 15	Skill 16	Skill 17	Skill 18	Skill 19	Skill 20	Skill 21	Skill 22	Skill 23	Skill 24	Skill 25	Skill 26	Skill 27	Skill 28
1	1	1	2	1	0	1	1	2	1	2	1	1	0
1	1	2	1	2	0	2	1	2	1	1	1	1	1
1	1	2	1	2	0	2	1	2	1	1	1	1	1
1	0	1	0	0	1	0	1	1	1	1	2	1	1
1	1	2	2	1	1	2	0	1	0	1	1	0	0
1	0	3	1	2	1	2	2	2	1	1	1	1	1
1	0	1	0	0	1	0	1	1	1	1	1	1	1
1	0	1	0	0	1	0	1	1	1	1	1	1	1
1	0	1	0	1	1	1	1	0	0	0	1	0	1
0	0	1	0	1	1	0	1	0	1	0	1	0	1
0	1	1	1	0	1	0	0	0	1	0	1	0	0
1	0	0	0	0	1	0	1	0	1	1	1	0	0
1	0	0	0	0	1	0	1	0	1	1	1	0	0

Skill 29	Skill 30	Skill 31	Skill 32	Skill 33	Skill 34	Skill 35	Skill 36	Skill 37	Skill 38	Skill 39	Skill 40	Skill 41
1	2	2	1	1	1	2	1	1	1	1	1	1
1	2	2	0	1	0	0	1	2	1	1	1	1
1	2	2	0	1	0	0	1	2	1	1	1	1
2	2	1	2	1	0	1	3	2	1	2	2	1
1	1	2	2	2	1	1	1	2	1	1	1	1
1	1	1	3	2	1	1	1	0	1	1	1	1
2	2	1	2	1	0	1	3	2	1	1	1	1
2	2	1	2	1	0	1	3	2	1	1	1	1
0	0	0	2	0	1	0	0	0	1	1	1	1
0	0	0	1	1	1	0	0	0	1	1	1	1
1	1	1	1	2	1	1	1	2	1	1	1	1
0	1	1	1	0	1	0	0	1	1	1	1	0
0	1	1	1	0	1	0	0	1	1	1	1	0

Table 2:Employee vs Skill

Skill 1	Skill 2	Skill 3	Skill 4	Skill 5	Skill 6	Skill 7	Skill 8	Skill 9	Skill 10	Skill 11	Skill 12	Skill 13	Skill 14
0	1	0	1	0	0	0	0	0	0	0	1	1	1
0	1	0	0	1	0	0	0	0	0	1	1	1	1
0	1	0	0	1	0	0	0	0	0	1	1	1	1
1	1	0	0	1	1	1	0	1	0	0	0	1	0
1	1	0	0	1	1	1	0	1	0	0	0	1	0
1	1	0	0	1	1	1	0	1	0	0	0	1	0
1	1	0	0	0	0	0	0	1	1	0	0	1	0
1	1	0	0	0	0	0	0	1	1	0	0	1	0
1	1	1	0	1	0	0	1	0	0	0	0	0	0
1	1	1	0	1	0	0	1	0	0	0	0	0	0
1	1	1	0	1	0	0	1	0	0	0	0	0	0
1	1	1	0	1	0	0	0	0	0	0	0	0	0
1	1	1	0	1	0	0	0	0	0	0	0	0	0

Skill 15	Skill 16	Skill 17	Skill 18	Skill 19	Skill 20	Skill 21	Skill 22	Skill 23	Skill 24	Skill 25	Skill 26	Skill 27	Skill 28
0	1	0	1	1	0	1	1	1	1	0	1	1	0
1	0	0	1	0	0	0	1	1	1	0	1	1	1
1	0	0	1	0	0	0	1	1	1	0	1	1	1
1	0	0	0	0	1	0	0	0	0	1	1	0	0
1	0	0	0	0	1	0	0	0	0	1	1	0	0
1	0	0	0	0	1	0	0	0	0	1	1	0	0
0	0	1	0	0	1	0	0	0	0	1	1	0	0
0	0	1	0	0	1	0	0	0	0	1	1	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0

Skill 29	Skill 30	Skill 31	Skill 32	Skill 33	Skill 34	Skill 35	Skill 36	Skill 37	Skill 38	Skill 39	Skill 40	Skill 41
1	0	1	1	0	1	0	1	1	1	0	0	0
1	0	1	0	1	0	0	1	1	1	1	0	1
1	0	1	0	1	0	0	1	1	1	1	0	1
0	1	0	0	1	0	1	0	0	1	1	0	1
0	1	0	0	1	0	1	0	0	1	1	0	1
0	1	0	0	1	0	1	0	0	1	1	0	1
0	1	0	0	1	0	1	0	0	1	1	1	1
0	1	0	0	1	0	1	0	0	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1	1
0	1	0	0	0	0	0	0	0	1	1	1	0
0	1	0	0	0	0	0	0	0	1	1	1	0

Table 3: Employee-Program Assignments(Decision Variables)

Program1	Program2	Program 3	Program4	Program5	Program 6	Program7	Program8	Program 9	Program10	Program11	Program12	Program13	Program14	Program15
b 0	b 0	b 0	b 0	b 0	b 0	b 0	b 0	b 1	b 1	b 1	b 0	b 1	b 1	b 0
b 0	b 1	b 0	b 1	b 0	b 0	b 0	b 1	b 0	b 1	b 0	b 0	b 1	b 0	b 0
b 0	b 1	b 0	b 1	b 0	b 0	b 0	b 1	b 0	b 1	b 0	b 0	b 1	b 0	b 0
b 0	b 1	b 0	b 1	b 0	b 1	b 0	b 0	b 1	b 1	b 1	b 0	b 0	b 0	b 0
b 1	b 1	b 0	b 0	b 0	b 1	b 0	b 0	b 0	b 1	b 0	b 0	b 1	b 1	b 0
b 1	b 0	b 0	b 0	b 1	b 0	b 1	b 0	b 0	b 0	b 1	b 0	b 1	b 0	b 1
b 0	b 0	b 0	b 1	b 0	b 1	b 0	b 0	b 1	b 1	b 1	b 0	b 0	b 0	b 0
b 0	b 0	b 0	b 1	b 0	b 1	b 0	b 0	b 1	b 1	b 1	b 0	b 0	b 0	b 0
b 1	b 1	b 0	b 0	b 0	b 0	b 1	b 0	b 0	b 0	b 0	b 0	b 0	b 0	b 1
b 0	b 0	b 0	b 0	b 1	b 0	b 1	b 0	b 0	b 0	b 0	b 0	b 0	b 0	b 1
b 0	b 0	b 0	b 0	b 1	b 1	b 0	b 0	b 0	b 1	b 0	b 0	b 0	b 1	b 0
b 0	b 0	b 0	b 0	b 0	b 0	b 1	b 0	b 1	b 1	b 0	b 0	b 0	b 0	b 0
b 0	b 0	b 0	b 0	b 0	b 0	b 1	b 0	b 1	b 1	b 0	b 0	b 0	b 0	b 0

Table 4:Total Cost - Total Usage of the Programs

	Program1	Program2	Program 3	Program4	Program5	Program 6	Program7	Program8	Program 9	Program10	Program11	Program12	Program13	Program14	Program15
TOTAL USAGE OF PROGRAMS	3	5	0	5	3	5	5	2	6	10	5	0	5	3	3
TOTAL COST OF PROGRAMS	1500	1500	0	2875	2400	2000	1000	2000	1200	5000	3500	0	2000	2700	2100

Table 5:Skill cost table

skill 1	25	skill 22	0
skill 2	1250	skill 23	0
skill 3	325	skill 24	0
skill 4	0	skill 25	725
skill 5	625	skill 26	25
skill 6	0	skill 27	0
skill 7	600	skill 28	0
skill 8	350	skill 29	0
skill 9	300	skill 30	0
skill 10	0	skill 31	0
skill 11	200	skill 32	200
skill 12	0	skill 33	400
skill 13	375	skill 34	700
skill 14	300	skill 35	2625
skill 15	500	skill 36	400
skill 16	700	skill 37	0
skill 17	0	skill 38	4975
skill 18	400	skill 39	0
skill 19	0	skill 40	0
skill 20	500	skill 41	1250
skill 21	0		