

Gaming as Educational Technology and the Evaluation of Gaming Results

The Experiment of Sweden Game

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Abstract—In this research, we conducted the Sweden game and described its educational effect. The Sweden game is one way to determine cost-sharing for the construction of a pipeline. Three groups of about 40 students were used, with each group consisting of six teams. A good solution was obtained. Additionally, students learned practical methods, how to strategize, and how to bargain. We realized that this experiment resulted in a desirable educational effect. We also evaluated the results of the Sweden game.

Keywords—component; gaming; sweden game; students education

I. INTRODUCTION

In recent years, gaming has gradually been recognized by many people as a new and promising tool to deal with complex problems in which human decisions have far reaching effects on others. It has been used for various purposes such as education, training, decision-making, entertainment, and etc.[1]. Along with the appearance of various types of games, continuous effort has been put forth in order to make existing games more exciting [2].



FIGURE I. SIX REGIONS OF THE SOUTH-EAST AREA OF SWEDEN, PLANNING PIPE-LINE CONSTRUCTION.

In this research, we conducted the Sweden game and described its educational effect. The Sweden game is one kind of “Education Gaming”. Education Gaming attempts to educate and train all participants. For example, in one such game there was an assumption that participants did not have much interest in economics. After playing the game for a few hours, the participants noticed their lack of basic knowledge and felt the need to learn economics more deeply. The result was that this game had a very significant educational benefit [3].

The management game is a kind of Education Gaming which focuses on training. It is made for people working in a middle-class stage of companies. When a person is promoted to a position that has a direct impact on the management of a company, there is the possibility of significant “Risk”. This is because when a person who lacks experience is entrusted with important business, he or she may not know the appropriate action. To help in such a situation, playing a game which simulates the management of the company again and again will help enable the person to master “how to manage the company” without entailing a greater risk.

II. SWEDEN GAME

Figure 1 shows the six regions, A, H, K, L, M and T in the south area of Sweden. These six regions are planning to construct pipelines to cooperatively procure the water resource. The kinds of cooperation, A, H, K, L, M and T are $2^6-1=63$. We show the cost for pipeline construction in Table 1. We show the population of each region and the spending quantity on water in Table 2. Of course, every area wants to minimize its financial expense for pipeline construction as much as possible. Under such a situation, what is the final conclusion? One method is the proportional distribution of an amount demand. Another method is the proportional distribution by population. Generally, these approaches are good determination methods. In this situation, it is necessary to construct in all regions the pipeline from the whole region viewpoint.

However, as shown in Tables 1 and 2, these are not necessarily proportional to the construction expense. When such difficulty arises, the method of dividing equally is often used. Table 2 shows the results of game playing by the water-resources staff and graduate school students of Sweden. Table 3 shows the assessed contribution according to the Shapley value, Nucleolus and SCRB. The result of game playing shown

in Table 3 is considerably different from the result of an assessed contribution by the Shapley value, Nucleolus and SCRB in Table 4. It is very interesting that there are different values from the ratio of each district population or the ratio of each district amount of water demand [4].

TABLE I. THE COST OF PIPELINE CONSTRUCTION. (UNIT: 100,000 CRONE)

Team	Cost	Team	Cost	Team	Cost	Team	Cost
A	219.5	KM	314.5	HKL	425.5	AKLM	639.6
H	170.8	KT	328.9	HKM	449.4	AKLT	707.2
K	108.1	LM	311.0	HKT	458.1	ALMT	734.1
L	158.8	LT	378.6	HLM	469.8	HKLM	480.7
M	208.1	MT	394.1	HLT	564.9	HKLT	492.4
T	219.8	AHK	407.4	HMT	420.1	HKMT	593.5
AH	346.9	AHL	432.2	KLM	487.7	HLMT	644.1
AK	328.6	AHM	555.0	KLT	487.7	KLMT	566.1
AL	378.3	AHT	566.7	KMT	503.2	AKMT	722.7
AM	427.6	AKL	487.4	LMT	514.6	AHKLM	697.6
AT	439.3	AKL	534.0	AHKL	489.5	AHKMT	774.2
HK	229.6	AKM	548.5	AHKM	602.5	AHLMT	830.0
HL	250.0	AKT	530.5	AHKT	627.2	AHKLT	709.3
HM	378.9	ALM	598.1	AHLM	640.3	AKLMT	739.7
HT	390.6	ALT	613.6	AHLT	652.0	HKLMT	664.6
KL	267.9	AMT	272.6	AHMT	741.0	AHKLMT	838.2

TABLE II. POPULATION AND THE QUANTITY OF SPENDING WATER OF EACH REGION.

	A	H	K	L	M	T
Population(1000)	85.0	176.3	26.8	69.0	287.3	59.5
Amount demand(Mm ³ /Year)	6.72	8.23	3.75	3.53	14.64	5.39

TABLE III. FINAL RESULT OF GAME PLAYING OF WATER-RESOURCES PERSON AND GRADUATE SCHOOL STUDENTS OF SWEDEN

	A	H	K	L	M	T
Game 1	211.5	97.0	60.0	91.0	183.5	195.0
Game 2	181.5	127.7	81.0	132.5	129.0	186.5

TABLE IV. THE ANSWER OF FOLLOWING METHODS

	A	H	K	L	M	T
Shapley value	200.1	107.1	66.1	103.7	169.4	191.8
Nucleolus	203.5	120.6	50.0	86.1	186.0	192.1
SCRB	195.4	132.8	56.2	109.0	166.6	178.2

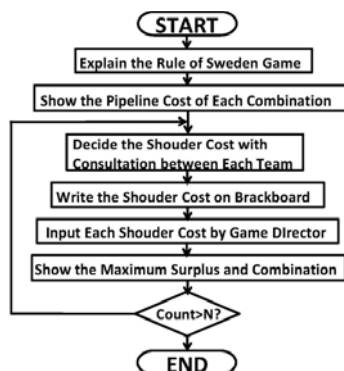


FIGURE II. FLOW CHART OF SWEDEN GAME EXPERIMENT.

III. EXPERIMENT

Our class of 14th grade College of Technology students have participated in the experiment since 2010. In Tables 5, 6 and 7, we show the results of the experiment of 7 terms for 43 students on Nov. 9, 2010. In Tables 8, 9 and 10, we show the results of the experiment for 4 terms for 46 students on Nov. 15, 2011.

	A	B	C	D	E	F
1	A	203.5				
2	H	120.6				
3	K	50				
4	L	86.1				
5	M	186				
6	T	192.1				
7		838.3				
8	Combination of Maximum Surplus		Maximum Surplus			
9	AHKLMT		0.1			
10			Surplus			
11	A	219.5	-16			
12	H	170.8	-50.2			
13	K	108.1	-59.1			
14	L	158.8	-72.7			
15	M	208.1	-22.1			

FIGURE III. THE EXAMPLE OF THE VIEWER FROM PROJECTOR BY MICROSOFT EXCEL.

Before starting the game, we explained to the students in advance the pipeline construction cost of all combinations. There are about 40 participating students. They were divided into three groups; one group has 6 teams, A, H, K, L, M and T. One team consists of two or three people. We show the flow chart of the Sweden Game experiment in Fig. 2 [5].

TABLE V. EXPERIMENTAL RESULTS OF GROUP1 ON 9 NOV. 2010.

Count	A	H	K	L	M	T	Maximum	Combination
1	210	155	60	133.8	178.1	202.7	101.4	AHKLMT
2	185	130	58	95	160	190	10.4	HKL
3	190	137	58	96	168	190	18.4	HKL
4	250	110	58	96	175	185	35.8	AHKLMT
5	208.5	130	58	95	175	185	13.3	AHKLMT
6	195.2	130	58	95	175	185	10.4	HKL
7	232	125	57	88	185	195	43.8	AHKLMT

TABLE VI. EXPERIMENTAL RESULTS OF GROUP2 ON 9 NOV. 2010.

Count	A	H	K	L	M	T	Maximum	Combination
1	180	162.7	65	120	208.1	180	77.6	AHKLMT
2	180	118.3	53.8	88.8	195	202.3	3.2	MT
3	180	147.3	53.8	88.8	195	173.3	17.3	HKL
4	200	100.8	8.2	266.4	3.5	2	15	AHL
5	184.8	126	55.8	90	199.8	181.8	0	AHKLMT
6	205	120.8	50	128	150	181.8	26.2	HKL
7	256	112.8	52	68	182	181.8	36.5	A

TABLE VII. EXPERIMENTAL RESULTS OF GROUP3 ON 9 NOV. 2010.

Count	A	H	K	L	M	T	Maximum	Combination
1	197.8	141.9	80	100	180	190	58.7	AHKLMT
2	170	130.8	66.6	98.7	180.2	150	23.5	HKL
3	170	0.8	60	77.7	180.2	185	27.9	AHKLMT
4	160	50	81.3	70	180.3	192	21.8	AHKLMT
5	160	70	76.7	68	191.2	202.9	0	MT
6	160	888.8	40.4	90	191.2	202.9	748.7	HKLMT
7	180	3.1	0.1	85	191.2	202.9	0	MT

TABLE VIII. EXPERIMENTAL RESULTS OF GROUP1 ON 15 NOV. 2011.

Count	A	H	K	L	M	T	Maximum	Combination
1	204.5	125.6	59.1	115	175	200	41	AHKLMT
2	200	120	52.9	110	172	193.2	10.3	HKL
3	200.2	120	52.9	99.7	172.2	193.3	0.1	AHKLMT
4	200.2	119.9	52.9	99.7	172.2	193.3	0	AHKLMT

TABLE IX. EXPERIMENTAL RESULTS OF GROUP2 ON 15 NOV. 2011.

Count	A	H	K	L	M	T	Maximum	Combination
1	210	117	109.1	117.5	160	0	71	HKL
2	205	70	52.8	103.7	170	199.9	-8.3	AKLMT
3	205	75	57.6	99.4	180	300	2.3	AKLMT
4	838.2	0	57.6	99.1	200	3	618.7	A

TABLE X. EXPERIMENTAL RESULTS OF GROUP3 ON 15 NOV. 2011.

Count	A	H	K	L	M	T	Maximum	Combination
1	198	129.4	58	90	170	185	4.8	HKL
2	200	123.3	54.2	95	165	210	9.3	AHKLMT
3	200	123.3	52.1	90	165	207.8	0	AHKLMT
4	197	105.8	51.5	90	77.7	211	-8.8	T

A. How to View the Results

We prepared the report sheet. When each team decided the shoulder charge, a player wrote down the cost on their report sheet and passed it to the game director. The game director inputted each term value in a laptop computer on the teacher's desk. The maximum surplus value was calculated and the combination of teams was shown when the maximum surplus value was reached. These were calculated by Microsoft Excel and shown to the students by projector. We show the example of the viewer from projector in Fig. 3. The game director wrote down the shoulder charge of each team, the maximum surplus value and the combination of teams on the blackboard.

B. Experimental Results

Each team wants to decrease the amount of their contribution as much as possible. However, if one team tries to save on the shoulder cost, other teams may not join them. When each team cooperates with the others a surplus as large as possible can be attained.

However, the best condition is that 6 teams, "AHKLMT" construct a tie-up and the amount of the maximum surplus is just zero. Furthermore, in the situation where the maximum surplus is just zero for the 6 teams "AHKLMT" due to cooperation, it is important that each team saves the suitable shoulder cost.

Each team has about 10 minutes before deciding their shoulder cost. Consultation between each team is also allowed. The good solution was obtained by the 5th waging war of group 2 on the experiment of Nov. 2010. The good solution was obtained by the 4th waging war of group 1 on the experiment of Nov. 2011. In these situations the maximum surplus is just zero because of the 6 teams "AHKLMT" cooperation. On the other hand, when several teams made a combination "HKL", at the 3rd waging war in Table.5, the team "AMT" was removed from the combination. Because team "AMT" proposed only little shoulder cost. However, at the 4th waging war in Table.5, team "AMT" proposed more shoulder cost, all 6 teams could make cooperation.

The square error by the 5th waging war of group 2 was 43.69. However, the square error by the 4th waging war of group 1 was only 19.08. The square error is the comparison with the Shapley value. We can get quite a good solution compared to the Shapley value.

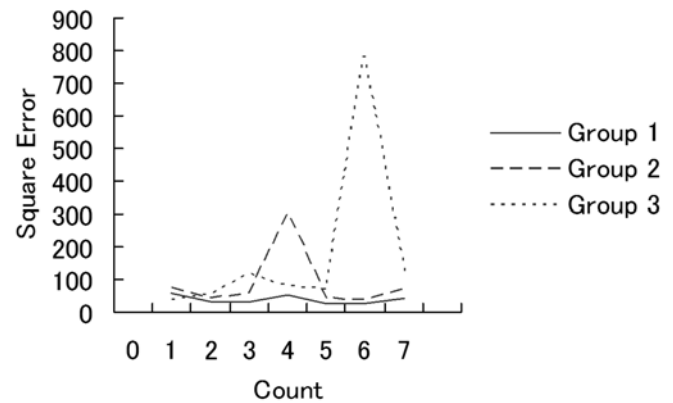


FIGURE IV. THE SQUARE ERROR OF EACH GROUP ON 9 NOV. 2010.

TABLE XI. EXAMPLES OF GOOD ANSWER, EACH SHOULDER COST, COMBINATION IS "AHKLMT" MAXIMUM LESS THAN 2.0.

Result	A	H	K	L	M	T	Maximum	Remark
1	184.8	126	55.8	90	199.8	181.8	0	Group2, 5 th , 2010
2	200.2	119.9	52.9	99.7	172.2	193.3	0	Group1, 4 th , 2011
3	200	123.3	52.1	90	165	207.8	0	Group3, 3 th , 2011
4	196.7	109.3	64.8	98.4	178.4	190.6	0	Group2, 5 th , 2012
5	192.3	107.8	60	84	197	197.1	0	Group3, 4 th , 2012
6	190	115.5	59.1	98	174	202.56	0.96	Group2, 4 th , 2014

We showed only pipeline construction costs to students. Even though students did not know the Shapley value, we got the good results. In addition, we also got the very good solution, the maximum surplus equal zero. Figure 4 shows the sum of squared error between the game result and the Shapley value on 9 Nov. 2010. In Group 2 and Group 3, there is a portion of protruding large square error. The cause may be that students did not addressed situation seriously.

C. Evaluation of the Answers by Comparison with SHAPLEY Value

We had more experiments of 5 terms for 40 students on Nov. 20, 2012, 3 terms for 35 students on Nov. 25, 2013 and 4 terms for 46 students on Oct. 23, 2014. We obtained some good answers of Sweden Game for the past six years' experiences from 2010 to 2015. Table 10 shows 6 examples of good answers. We picked up the data which the maximum surplus is less than 2.0 and the combination is "AHKLMT".

TABLE XII. THE DIFFERENCE BETWEEN THE SHAPLEY VALUES OF TABLE XI.

Result	A	H	K	L	M	T	Max	Remark
1	15.3	-18.9	10.3	13.7	-30.4	10	0	Group2, 5 th , 2010
2	-0.1	-12.8	13.2	4	-2.8	-1.5	0	Group1, 4 th , 2011
3	0.1	-16.2	14	13.7	4.4	-16	0	Group3, 3 th , 2011
4	3.4	-2.2	1.3	5.3	-9	1.2	0	Group2, 5 th , 2012
5	7.8	-0.7	6.1	19.7	-27.6	-5.3	0	Group3, 4 th , 2012
6	10.1	-8.4	7	5.7	-4.6	-10.8	0.96	Group2, 4 th , 2014
Ave	6.10	-9.87	8.65	10.35	-11.7	-3.73		

TABLE XIII. THE COST OF PIPELINE CONSTRUCTION, COMBINATION "AKL" AND "HMT". (UNIT: 100,000 CRONE)

	A	K	L	Subtotal	AKL	Saved
Cost	219.5	108.1	158.8	486.4	487.4	-1.0

	H	M	T	Subtotal	HMT	Saved
Cost	170.8	208.1	219.8	598.7	420.1	178.6

TABLE XIV. THE EXPERIMENT RESULTS OF EACH GROUP OF 3RD COUNT ON NOV. 2015.

Group	A	H	K	L	M	T	Max	Combination
1	189.4	101.8	81	89.8	200.8	175.4	0	AHKLMT
2	186.8	105	67.6	100	183.6	195.2	0	AHKLMT
3	191	115	65	92.2	185	190	0	AHKLMT
4	190	92	68.2	110	181.5	190	0	AHKLMT
5	200	85	70	100	169.7	200	0	AHKLMT
6	188.4	100	84	88.6	188.8	188.4	0	AHKLMT
7	187	189.4	120	92	170	172.4	129	HKL

TABLE XV. THE DEFFERENCE WITH SHAPLEY VALUE AND SQUARE ERROR OF 3RD COUNT ON NOV. 2015.

Group	A	H	K	L	M	T	Sq. Error
1	10.7	5.3	-14.9	13.9	-31.4	16.4	42.6
2	13.3	2.1	-1.5	3.7	-14.2	-3.4	20.3
3	9.1	-7.9	1.1	11.5	-15.6	1.8	22.9
4	10.1	15.1	-2.1	-6.3	-12.1	1.8	22.9
5	0.1	22.1	-3.9	3.7	-0.3	-8.2	24.2
6	11.7	7.1	-17.9	15.1	-19.4	3.4	33.5
7	13.1	-82.3	-53.9	11.7	-0.6	19.4	101.8

They are considerably different from the result of an assessed contribution by the Shapley value. Table 12 shows the difference between the Shapley values. If this difference is a plus value, this team requires less shoulder costs. It means it is advantageous for the people in this district. In the case of the difference is a minus value, this team requires more shoulder costs. It means it is disadvantageous for the people in this district. However, team "A","K" and "L" have an advantageous tendency. On the other hand, team "H","M" and "T" have a disadvantageous tendency.

In Table 13, we show the cost of pipeline construction, combination "AKL" and "HMT". In the combination of "AKL", the subtotal cost is 486.4. However, combination cost is 487.4, it is higher than the subtotal cost which is a summation of each shoulder cost. It is the reason that the combination of "AKL" does not appear in the result of gaming. On the other hand, in the combination of "HMT", the subtotal cost is 598.7. However, the combination cost is only 420.1. The team "HMT" can save

the shoulder cost by making the combination. For the team "HMT", in the combination of six regions, the shoulder cost is higher than in the combination of only three "HMT" regions. It is the reason why team "H","M" and "T" have the disadvantageous tendency in table 12. In the result of gaming, we got the answer concerning the interest of each team.

For the past five years from 2010 to 2014, we divided the classroom into three groups. There were two or three people in one team. However, we have divided the classrooms into seven groups in the experience on October 29, 2015. There was only one person in one team. Thus the student could join the game aggressively without depending on others. All 7 groups and each 6 teams shoulder cost, the maximum-surplus and the combination are entered on the blackboard. Thus, participants can uplift the competitive spirit. Even though we have only three terms of gaming experience, we have the good answer shown in Table 14. Table 14 means 6 groups in the 7 groups get the complete solution, maximum-surplus is 0 and the combination is "AHKLMT". Moreover, it is interesting that each shoulder cost has the variation between other groups. However, they got the good solution because the almost square errors were only 20 or 30 shown in Table 15 [6].

IV. CONCLUSION

We carried out the Sweden game. We created three groups of about 40 students. One group consisted of six teams. We had the good solution by the 5th waging war of group 2 on the experiment of Nov. 2010 and by the 4th waging war of group 1 on the experiment of Nov. 2011. The square error compared with the Shapley value was only 19.08 by the 4th waging war of group 1. On the experiment of Nov. 2015, even though we had only three terms of gaming experience, we had the good answer, the almost square errors were only 20 or 30. From students' opinions, we believe that students learned practical methods and the way of strategy and bargaining. Students were also interested in this Sweden game. The education effect will increase by the fact that students play the game with interest. We realized that this experiment brought the educational effect. In the result of gaming, we got another answer concerning the interest of each team. It is different features than the Shapley value. Playing this game required teamwork in a stressful environment under the relationships of money and benefit. It is good real-world training for students.

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