How can we ensure middle school students acquire economic thinking?

Developing and evaluating an analog game involving smartphones simulated with LEGO blocks

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Abstract. In economic education, it has become increasingly important for middle school students to acquire economic thinking. We developed an analog game using LEGO blocks for students to gain perspective on economic issues. In this game, we treated combined LEGO blocks as smartphones, and the students "produced" and "traded" LEGO blocks to engage in economic activities. Using this game, we conducted economic education classes in two middle schools. We clarified whether students were able to master economic viewpoints through the lesson. To achieve this objective, we conducted a questionnaire survey on opportunity costs before and after the lesson, and used the Financial Fitness for Life Theme tests. Students could make decisions after comparing profits and losses resulting from the consequences of their choices. More than half the students selected the correct answer for applied questions using the opportunity cost concept. However, about three-fourths of the students could not define opportunity cost.

Keywords: active learning, economic education, opportunity cost

1 Introduction

Uncertainty surrounding individuals' decision-making ability is growing due to changes in social structure; simultaneously, instances where individuals are compelled to make decisions are also increasing. Under these circumstances, economic education has become even more important for middle and high school students. Economic thinking is a conceptual framework for understanding economic phenomena and grasping their essence, but the notion has two meanings: the "general meaning of things" and "universal knowledge." An example of the former is knowledge of "economic activity, economic systems, and their functions" while the latter refers to "a way of thinking unique to economics, reflecting economic theory" [1]. According to the teaching guidelines for Japanese middle schools, students should come to understand that "in the market economy, individuals and companies select how much to produce and consume

while considering prices" [2]. As a method of dealing with content, students learn that in specific cases, "the economic activities of individuals and companies are carried out by selection under various conditions" [2]. Conversely, textbooks are focused on facts and institutions and it is difficult for students to acquire economic thinking reflecting economic theory. Kanou [3] asserted that it is possible to acquire economic thinking from textbooks by asking "why" questions, but students find such questions challenging because, with the exception of making purchases, they lack economic experiences. To overcome this challenge, students need to conduct activities in the market economy and reflect on such tasks through gaming. The effectiveness of gaming in economic education, in relation to traditional lecturing, has been assessed as a means of conveying economic insights and principles [4]. However, since most studies on gaming for economic education have only been targeted at undergraduate students, it is difficult to put economic education reflecting economic theory into practice for middle school students.

2 Research goals and methodology

We developed an analog game using LEGO blocks to help middle school students gain economic thinking, especially focusing on opportunity cost[1], a key concept in economics. The reason for this focus is because, although opportunity cost is arguably the most fundamental concept in economic reasoning, even economists who hold PhDs find it difficult to completely understand [6].

We treated combined LEGO blocks as if they were smartphones, and the students produced and traded the blocks to engage in economic activities. Since learners' decision-making and the outcomes of most games are self-explanatory, they are usually only able to acquire one decision criterion [7]. However, in the game we developed, since the economic environment changes dynamically (in terms of interactions) as players trade with each other, the participants gradually came to understand the decision-making criteria according to fluctuating circumstances. We asked students to describe the thought processes that accompanied their decisions, as well as to contrast their own thoughts with economic thinking reflecting economic theory, facilitating enhanced learning.

The goal of this study was to clarify whether students were able to master economic viewpoints, in particular the concept of opportunity cost, by playing this game, and whether they could make rational decisions in a changing environment using fundamental concepts of economics.

Using this game, we gave classes on economic education at two middle schools (teaching a total of 57 students). To achieve these objectives, we conducted a questionnaire survey on opportunity costs before and after the lesson, and used the Financial Fitness for Life Theme (FFFL) tests developed by the National Council on Economic Education [8]. In the questionnaire survey, we asked the respondents about kinds of costs they value in daily selection both before and after the lesson. In the context of

[1] Opportunity cost is the next best alternative that is given up when a choice is made. It is an essential concept for rational decision making because it is a correct measure of the costs of everything we do [5].

cooking curry, we asked the participants which factors they emphasized when they decided to cook themselves, rather than buying naan (an Indian bread that is eaten with curry). We also asked about sunk costs spent on making curry, as well as material expenses, direct costs (the material expense of naan) and opportunity costs (the time spent making naan). In addition, we asked the respondents about their views on the economy via a questionnaire survey. The survey aimed to explore how their perspectives on the economy changed before and after the lesson.

3 Analog game involving smartphones simulated with LEGO blocks

3.1 Outline of the game

In this game, the value of a smartphone made from LEGO blocks depends on the colors of the combined blocks. The combination of the most valuable colors consists of 4 points, while the blend with the lowest value is 1 point. The team with the highest total score wins. We divided the participants into eight teams, with each one representing a different color; we gave each team 14 LEGO blocks with which they could obtain the highest score. The maximum number of points that can be obtained using the blocks given at the beginning is 8 points. This condition was the same for every team.

Each team can choose either “trade” or “production” as a way to get a new block. *Trade* means that teams exchange blocks, while *production* means that a team increases the number of blocks in its stockpile by adding a block of the color that the team represents. Each team can select whether to trade or produce while referring to the number or color of the blocks in their stockpile. By setting this rule, we offered participants the opportunity to learn rational decision-making, especially the concept of opportunity cost.

This game consists of three phases (Figure 1), and teams can choose to either trade or produce five times in each phase. In the first phase, it is only possible to trade within a group of four teams, but in the second phase, trade is possible between all eight teams. Since a group that can trade during the second phase possesses blocks for making highly valuable smartphones (that each other group can acquire), it is advantageous to trade with teams belonging to different groups. However, we did not explain this fact to the participants, expecting them to discover it themselves while observing others and negotiating.

In the third phase, if a team makes a smartphone worth 4 points that has the same color combination as another team’s smartphone, the score is reduced according to the number of overlapping colors. Given this rule, when making a smartphone worth 4 points, a team has to decide whether to consider the blend of colors of smartphones produced by other teams. This situation creates a social dilemma. If individual teams behave selfishly, not only will their scores fall, but all of the teams’ scores will also decrease. Thus, we provided opportunities for the participants to make decisions under fluctuating circumstances, while adding rules to simulate real economics in each phase.

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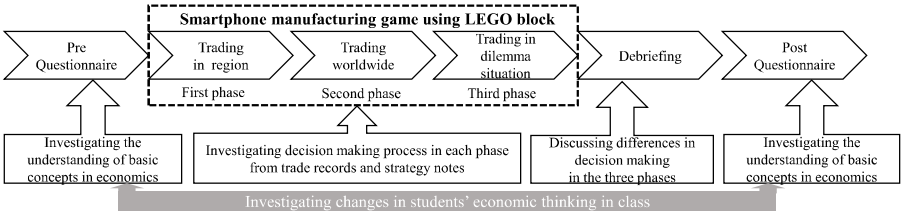

Fig. 1. Outline of the game whereby a smartphone is simulated with LEGO blocks

3.2 Implementing the game

We conducted the game in A school in July 2017 and B school in August 2017 without regard for the regular curriculum. The participants in A school consisted of 36 students (9 first year students, 16 second year students, and 11 third year students[2]), while the participants in B school comprised 21 students (all third year students). None of the participants were informed about economics or the content of the game in advance. Before playing the game, we administered a questionnaire survey on opportunity costs and impressions of the economy. Subsequently, we explained the rules of the game for approximately 15 minutes. Four college students in total who were familiar with the rules of the game assisted each team. Each phase lasted about 15 to 20 minutes. We asked each team to record the kind of trade it conducted with other teams. At the end of each phase, we asked each team to describe the strategy it had adopted, and to give reasons for why their score increased.

3.3 Outcomes of the game

Changes in cognition of the concept of opportunity cost before and after lesson. Based on the changes in cost that participants considered in terms of daily decisions before and after the lesson (Table 1), at A school, the items of opportunity cost (the time spent making naan) and direct cost (the material cost of naan) increased significantly after the lesson. Conversely, in B school, no significant difference was confirmed before or after any of the items. Regarding the reason for this, about half of the participants chose "agree" and "partially agree" for the items of opportunity and direct cost, both before and after the lesson; thus, we assume that the participants were already considering these ideas. We believe that the two schools experienced different results due to the composition of the participants. While all the participants at B school were in the third year, the participants of A school ranged from first year to third year. Although children in middle school classes rarely deal with opportunity costs, the economic thought of first and second year students with fewer economic experiences than third year students may have influenced the game.

Understanding the concept of opportunity cost. Figure 2 shows the results of the question asking participants to define opportunity cost. The correct definition is the "value of the next best alternative not chosen." The percentage of correct responses at

[2] In Japan, a first year middle school student is 13 years old.

A school was 22.2%, while the percentage of correct responses for B school was 10%. According to an earlier survey by Yamaoka [9], the proportion of correct responses among middle school students (n = 187) in Japan is 16.9%. In a survey targeting middle school students (n = 362) in the U.S., the correct response rate was 17% [8].

Table 1. Changes in perceptions of cost before and after the lesson (A school). The numbers indicate the number of respondents for each item. Statistics are p values measured using the Wilcoxon signed-rank test.

item	option	before lesson	after lesson	statistics
It is important to think about the price of naan being sold at supermarkets.	agree	20	24	*n.s.*
	partially agree	15	10	
	partially disagree	5	2	
	disagree	0	0	
It is important to think about the material cost spent making curry.	agree	18	23	*n.s.*
	partially agree	11	10	
	partially disagree	6	3	
	disagree	0	0	
It is important to think about the time spent making curry.	agree	11	20	$p < .05$
	partially agree	13	11	
	partially disagree	10	5	
	disagree	1	0	
It is important to think about the material cost when you make naan yourself.	agree	15	21	$p < .05$
	partially agree	15	14	
	partially disagree	5	1	
	disagree	0	0	
It is important to think about the time when you make nann yourself.	agree	12	23	$p < .05$
	partially agree	13	8	
	partially disagree	10	5	
	disagree	0	0	

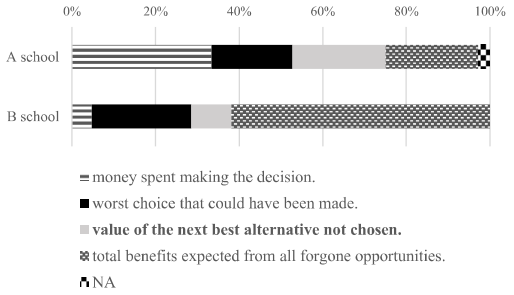

Fig. 2. Which is the definition of opportunity cost of a decision?

Based on our game, it is hard to determine whether participants correctly understood the definition of opportunity cost. In the debriefing, we taught them that “opportunity cost” means “other choices you have to give up by making a certain choice” according

to the situation in the game; thus, we believe that it was difficult for the participants to select the correct answer. Meanwhile, 62% of the respondents at B school defined opportunity cost as "total benefits expected from all forgone opportunities." Since they could choose "production" or "trade" in the game, we think it highly probable that they misunderstood the phrase "all forgone opportunities."

Conversely, a higher number of participants chose the correct answer for the question about the concept of opportunity cost than the question about its definition. Figure 3 shows the answers to the question: "What is the opportunity cost of dropping out before you graduate from high school?" The correct answer is "higher wages in the future." The percentage of correct responses for A school was 47.2%, while that figure was 80.1% for B school. The proportion of correct responses for middle school students in an earlier survey was 65.8% [9], higher than in A school. However, all the subjects of the earlier survey were third year middle school students, and it *cannot* be said that the correct answer rate is remarkably low, considering that more than half the participants in our survey were middle school first and second year students. The correct answer rate for B school was much greater than that of the earlier survey for third graders only.

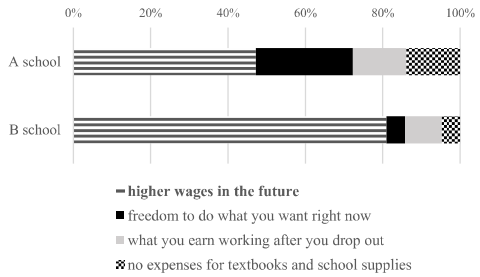

Fig. 3. What is the opportunity cost of dropping out before you graduate from high school?

The answer to the question in Figure 4 is also an application question using the concept of opportunity cost. We asked: "What is the opportunity cost of saving money?" The correct answer is "the products that could be purchased now." The percentage of correct responses for A school was 50.0%, while B school was 52.3%. Since the correct answer rate for this question in the earlier survey was 27.3%, both schools' percentages of correct responses were higher than those of the earlier survey [9].

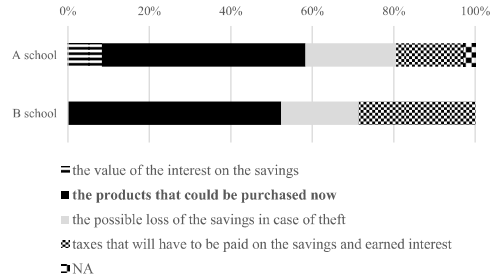

Fig. 4. What is the opportunity cost of saving money?

Changes in perceptions of the economy before and after the lesson. Figure 5 shows changes in participants' perceptions of the economy before and after the lesson. We asked them to freely describe their views, classifying the text data into multiple categories using SPSS Text Analytics for Surveys. In both schools, categories such as "money" and "difficult" were dominant in thoughts on the economy before the lesson, but the category of "opportunity cost" that we dealt with in the debriefing prevailed the most after the lesson. In both schools, categories related to the social system such as "stock," "tax," and "company" appeared before the lesson. However, after the lesson, categories of actions and thinking levels not described before the lesson such as "trading," "thinking," "strategy," "negotiation," and "selection" appeared.

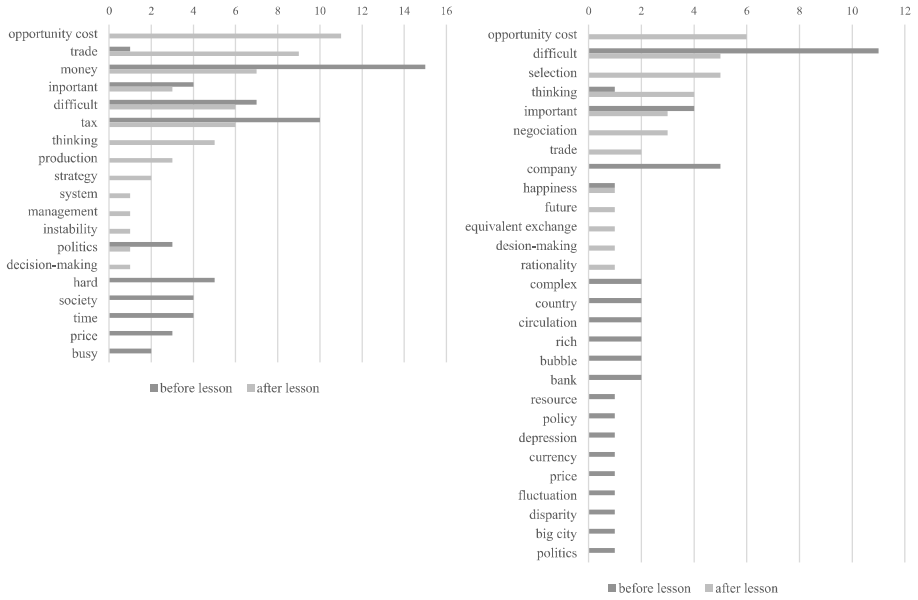

Fig. 5. What is your perception of the economy?
Left: A school; Right: B school

Participants' actions and strategies in the game. We considered the relationship between participants' actions and strategies in the game based on the "strategy sheet" and "trade record" described by the teams at the end of each phase. Comparing both schools, at A school, the average amount of production was 7.1 while that of trade was 7.6 at A school, and at B school, the average amount of production was 6.5 while that of trade was 8.5. In both schools, the quantity of trade was slightly higher than the amount of production, on average. Trade was most frequent in the second phase, followed by trade in the order of the first and third phases.

By analyzing the "strategy sheet" regarding a team's reasons for taking such actions, each team could recognize that others that could trade in the second phase possessed blocks for making high-value smartphones. Through such recognition, each team chose to actively trade. Essentially, participants could see that the profit obtained from trade

was greater than the profit obtained from production due to changes in the trading environment.

From the analysis of B school's strategy sheet, in the first phase, most teams only traded for their own benefit. Yet in the second phase, they could trade with the recognition that all teams that traded would benefit each other. In fact, in the second phase, the total score of all the teams increased. Based on this outcome, participants chose to trade after understanding that doing so not only benefited them, but others as well.

One team made smartphones using the same color in order to reduce the scores of other teams, while observing the color combinations of the smartphones other teams produced. Another team collected a large number of specific colored blocks through trade so as not to duplicate the color of the smartphone. Both strategies are techniques for outmaneuvering other teams by taking advantage of the rules introduced during the third phase. However, in the third phase, in order to avoid losses due to overlapping colors, the number of groups making smartphones worth 3 points (by producing the color of the block representing their teams) increased. Through these strategies, in the third phase, some teams increased their scores and others reduced their scores. Even at both middle schools, we did not observe behaviors coordinated with other teams to avoid losses; thus, the final score for all teams as an average was significantly lower than in the second phase.

4 Conclusion

The participants recognized the importance of opportunity cost, which is a fundamental concept of economics. They did so by reflecting on the implications of their actions according to environmental changes; they described their trade records, their strategies, and experienced debriefing during the game. More than half the students selected the correct answer for applied questions using the opportunity cost concept. However, approximately three-fourths of the students could not derive the definition of opportunity cost themselves since the number of action choices in the game was limited to two.

Conversely, using a questionnaire survey on a free description form, students could make decisions after comparing profits and losses resulting from the consequences of their choices; we found that they could rationally state the reasons for their decisions. Perhaps in this game, participants understood some aspects of rational decision-making, but we think that factors that affect decision-making in the three phases are isolated from each other and that some participants had "partial understanding of the economic system" that is not completely integrated [10]. In order to integrate various factors, it is necessary to advance the students' cognitive framework. Encountering an imbalance that causes perturbation of the cognitive framework is important for cognitive development. Regarding this point, initially, the students perceived the economy as a social system unrelated to them. However, by producing and trading blocks in the game, they realized that the economy is an important activity related to their decisions. They internalized the economic system through this game. We were able to provide the first step to help them acquire economic thinking.

Future work includes developing lessons that focus on opportunity cost and reflections during the debriefing. In the third phase, we assumed that a Pareto improvement would improve resource allocation without lowering any team's score. In this game, since the three-phase situation became complicated, we could not contend with Pareto improvements adequately. It will be necessary to reconsider the contents of the strategy confirmation sheet and debriefing at that point in time.

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