*Educational Technologies*
*Образователни технологии*

# BOARD GAME "MAKING FINANCIAL DECISIONS" IN THE SYSTEM OF TEACHING THE MATHEMATICAL FOUNDATIONS OF FINANCIAL LITERACY

**Bogdana Koneva, Maria Shabanova**
*Northern (Arctic) federal university named after M.V. Lomonosov (Russia)*

**Abstract.** The aim of this article is to present the theoretical model for the construction of tasks in improving financial literacy in algebra course at school and to submit the economic and mathematical game based on the developed model.

At the state level, a number of important documents have been adopted on the formation of financial literacy of schoolchildren, various measures are being implemented to solve this problem. Despite this, today the tasks presented in the school mathematics course do not fully solve the issue of increasing the level of financial literacy. In the course of work on the creation of a theoretical model for Teaching mathematical foundations of financial literacy, an analysis of Russian textbooks on mathematics was carried out, federal regulations and international standards were studied.

Our analysis allows us to assert that there are not enough tasks for the formation of financial literacy skills in the school course of mathematics. In addition, these tasks form initial knowledge in the financial sector. Also, the tasks are of the same type and often affect only two areas of handling finance. These are purchases and loans. Also, the tasks of the school mathematics course correspond only to the first level of the PISA standard.

Thus, it became obvious that it was necessary to develop a theoretical model for the construction of tasks in improving financial literacy in algebra course at school according with the System (frame) financial capability for school age pupils and PISA diagnostic model.

*Keywords:* financial literacy at algebra course; theoretical model; mathematical tasks; PISA; economic and mathematical game

## Introduction

In the modern world, a high level of financial literacy of the population is one of the most significant factors in the development of the economy of any state. The ability of most members of society to set financial goals and independently ensure their life cycle leads to an increase in their standard of living, confidence in the future and, consequently, to the stability of society and the development of the economy of the whole country. It is obvious that ensuring their life cycle requires a person to be able to calculate their financial

resources both in everyday situations and in the long term. However, experience shows that most people make decisions about spending their financial resources thoughtlessly, guided by momentary considerations, without taking into account risks, without making any preliminary calculations.

Today, more than 60 countries around the world are implementing programs to improve the level of financial literacy, which are an element of public policy. The Organization for economic co-operation and development (OECD) does a lot of work to coordinate national educational strategies and diagnose the results achieved. At the national level, special organizations funded from the state budget are most often engaged in solving these tasks: in the United States, the financial literacy and education Commission (FLEC); in Australia, the financial information Service (FIS); in Canada, the financial services consumer protection Service (FCAC); in the UK, the financial services Authority (FSA).

Solving the problems of improving the level of financial literacy of all categories of the population in Russia began in 2011 with the support of the world Bank. At the state level adopted a number of normative documents, regulating its decision, such as Strategy for financial literacy in the Russian Federation for 2017-2023[1)], Main directions of development of the financial market for the period 2019 -2021 years[2)], List of activities Ministry of education and science of Russia and Bank of Russia in improving the financial literacy of students of educational institutions in Russian Federation to 2017 – 2021[3)] etc.

Participation of Russian schoolchildren in international comparative studies PISA shows that some progress has been made. The problem area remains mastering the mathematical foundations of financial decision - making. In the Arkhangelsk region, this problem is solved by expanding the number of participants in the International Olympiad in financial and actuarial mathematics, established by two Bulgarian universities: the University of Economics – Varna and the Higher school of insurance and Finance (Nikolaev, Grozdev, Koneva, Patronova & Shabanova, 2019).

**Materials and Methods**

The PISA diagnostic model[4)] distinguishes five levels of financial literacy:

Level 1. Questions (requirements) tasks that include students in the activity of recognizing the purpose of daily financial documents, interpreting the information they provide.

Level 2. Questions (requirements) tasks that include students in the activity of assessing the significance of the information provided, disclosing useful links between pieces of information.

Level 3. Questions (requirements) tasks involving students in the activity of obtaining conclusions from the available data based on basic mathematical operations (simple calculations, changing the form of data presentation, comparing values).

Level 4. Questions (requirements) tasks that include students in the activities of mathematical modeling and research of the properties of the mathematical model of the situation in order to make optimal financial decisions.

Level 5. Questions (requirements) tasks that include students in the activities of a mor-

al choice between desires and needs, strategic planning of financial behavior, detailed justification of the optimality of financial decisions, etc.

Nowadays, tasks aligned with financial literacy in algebra course do not improve financial literacy of students at Russian secondary schools. They need to be modified according to PISA diagnostic model.

In the Strategy for improving financial literacy in the Russian Federation for 2017 – 2023[1)], ***"financial literacy"*** is defined as the result of the financial education process, which is defined as a combination of awareness, knowledge, skills and behavioral models necessary for making successful financial decisions and ultimately achieving financial well-being.

## Results and Discussion

### *Theoretical model*

In this regard, the category "Financial decisions" is the basis of our level model of financial literacy (Fig. 1).

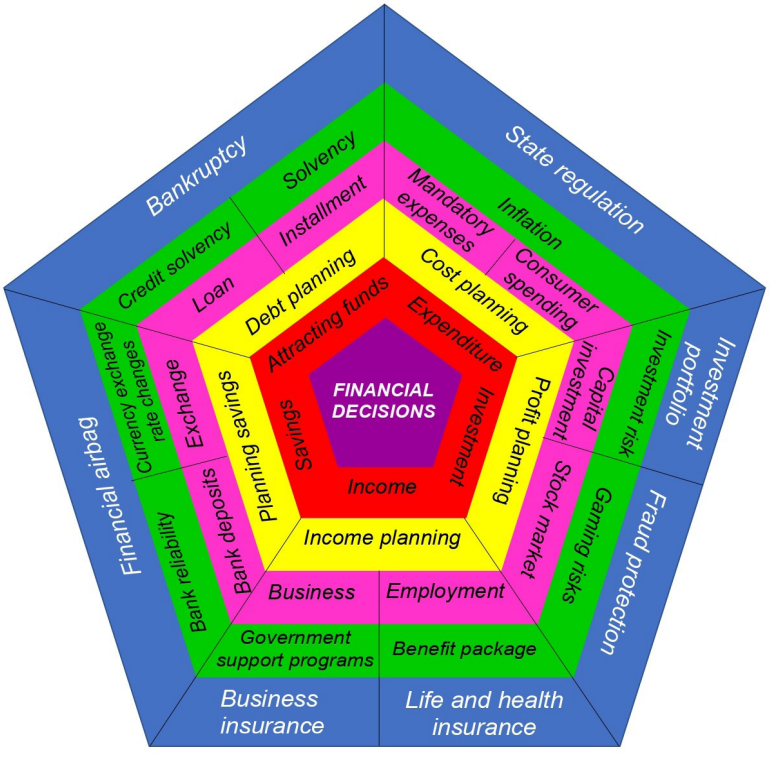


**Figure 1.** Theoretical model "Teaching mathematical foundations of financial literacy"

In this model, the levels are defined according to the complexity of the decisions made. According to this model, the first stage of teaching is to prepare the child to make good analyzed momentary decision (red sector). The second is to make financial plans (yellow sector). The third stage is the form knowledge necessary for decision-making based on a comparative analysis of alternative proposals (pink sector). The fourth is teaching in financial decision-making based on the analysis of the stability of the national and global markets (green). And the final stage is learning how to assess possible financial risks and how to minimize them (blue sector).

Our proposed model is conformed to System (frame) financial capability for school age pupils. The frame was developed through a joint project of the Ministry of Finance of the Russian Federation and the World Bank "Promoting the increase of the level of financial literacy of the population and the development of financial education in the Russian Federation"[5].

At each level, the model is implemented through learning in mathematical methods of decision-making in five main types of financial activities-sectors: income, investment, saving, expenditure and attracting third-party funds.

***Economic and mathematical game***

Didactic games are recognized means of developing financial literacy. A lot of examples of didactic games are published on the website of CJSC "PAKK" (http://edu.pacc.ru/materialy/). We took game scenario "Decision Making" as the basis of our proposed modification and developed economic and mathematical game based on our model.

*The aim* of the game is to maintain the financial decision made in an ever-changing environment

*The Game result.* If a player is forced to change his mind under the pressure of circumstances, then he loses and is eliminated from the game. The last player is considered to be the winner.

*The types of games.* Each decision-making game is assigned to a specific sector of the model (Fig. 1). Each game has 5 rounds assigned to the levels of the financial literacy model. Within one round, the altering in the situation is determined randomly by means of a tape measure and cards. Each round is an independent game.

*Equipment:* cards – legends describing financial proposals and starting conditions for their acceptance, rejection or optimal choice, roulette with types of new circumstances that are superimposed on the initially made decision and additional cards with amounts that specify them.

*Course of the game:*

1. Participants receive a card with a legend, make a decision and mathematically justify its correctness or optimality.

2. The players take turns spinning the roulette wheel and take one card with the amount, adjust their calculations. Then they announce the retention or change of the original decision.

3. The presenter of the game (teacher) and other players check the validity of the presented justifications.

4. If a player is forced to change his mind under the influence of circumstances, then he loses and out of the game.

The game has the *legend*. «Tanya saw a classmate's latest iPhone model and asked her dad to buy it. She agrees to wait with the purchase, but only until the salary day. Dad is raising his daughter alone and does not really want to refuse her. They learned that the cost of such mobile in the online shop is 60,000 rubles.

Imagine yourself in the place of Tanya's dad. Can you afford to give such a gift to your daughter if you are raising her alone, your average monthly income is 100,000 rubles. Family expenses for utilities averaged 6,000 rubles, food expenses are 20,000 rubles, transportation costs averaged 5,000 rubles, expenses for household purchases do not exceed 5,000 rubles per month, payment for mobile phones and the Internet is 2,500 rubles per month».

***Decision making of level 1*** (Fig. 1):

1) We find out the total amount of family expenses per month, adding up all items of expenses: 6,000 + 20,000 + 5,000 + 5,000 + 2,500 = 38,500. 38,500 rubles are monthly family expenses.

2) We find out how much of the pay will remain if all expenses are foreseen:

100,000 − 38,500 = 61,500 (rubles) - the remainder of the pay after all expenses.

3) 61,500 > 60,000

*Answer:* Yes, dad can buy it because the remaining money is more than the iPhone costs.

***Additional conditions*** of ***level 1*** are presented in the table 1. Student should choose two cards at random.

**Table 1.** The various cards of chance events on the first level

| *Chance event* | *Cards* |
|---|---|
| Your salary this month is | + 15%; + 10%; + 5%; + 3%<br>− 15%; − 10%; − 5%; − 3% |
| Your family's mandatory expenses this month is | |
| iPhone price on the day of purchase is | |

An example of chance event: iPhone price on the day of purchase increased by 10%. The solution of the problem in general form is as follows.

S is salary; s – the change in salary shown on the card;

E – monthly family expenses; e - change in expenses shown on the card;

P – iPhone price; p – change in price presented on the card;

Then $S \times (1 + \frac{s}{100})$ – salary after the chance event;

$E \times (1 + \frac{e}{100})$ – family expenses after the event;

$P \times (1 + \frac{p}{100})$ – iPhone price after the event;

If $S \times \left(1 + \frac{s}{100}\right) - E \times \left(1 + \frac{e}{100}\right) \geq P \times \left(1 + \frac{p}{100}\right)$,

then the buy opportunity condition is possible (winning position).

***Additional conditions*** of ***level 2*** are presented in the table 2. Student should choose three cards at random (1 – from stack of cards "event", 1 – from stack of cards "p" and 1 – from stack of cards "m"). The legend changes. "Dad promised Tanya to buy iPhone to her birthday which will be in 10 months. Tanya agreed with his proposal".

**Table 2.** The various cards of chance events on the second level

| Chance event | p, (%) | m, (month) |
|---|---|---|
| You will receive from bank A an offer of a term deposit in the amount from C (RUB) under p% to m (months) with the condition of accrual according to the simple interest scheme | 4; 5; 6; 7; 10; 12 | 4; 5; 6; 7; 10; 12 |
| You will receive from bank A an offer of a term deposit in the amount from C (RUB) under p% to m (months) with the condition of accrual according to the compound interest scheme | | |
| You will be approved a consumer (differentiated payment) credit in bank A in the amount of C (RUB) under p% for m (months) | | |
| You will be approved a consumer (annuity payment) credit in bank A in the amount of C (RUB) under p% for m (months) | | |

***Decision making of level 2*** (Fig. 1):

1) Deposit with the condition of accrual according to the simple interest scheme:

$$\left(S \times \left(1 + \frac{s}{100}\right) - E \times \left(1 + \frac{e}{100}\right)\right) \times \left(1 + \frac{p * m}{100}\right) \geq C \times (1 + \frac{c}{100})$$

2) Deposit with the condition of accrual according to the compound interest scheme:

$$\left(S \times \left(1 + \frac{s}{100}\right) - E \times \left(1 + \frac{e}{100}\right)\right) \times \left(1 + \frac{p}{100}\right) \times m \geq C \times (1 + \frac{c}{100})$$

3) Consumer credit (differentiated payment):

$$S \times \left(1 + \frac{s}{100}\right) - E \times \left(1 + \frac{e}{100}\right) \geq x_1, \text{ if } x_1 = C \times \left(1 + \frac{p}{100}\right) - \frac{(m-1) \times C}{m}$$

4) Consumer credit (annuity payment):

$$S \times \left(1 + \frac{s}{100}\right) - E \times \left(1 + \frac{e}{100}\right) \geq x_1, \text{ if } x_2 = \frac{C \times \left(1 + \frac{p}{100}\right) \times m \times \frac{p}{100}}{\left(1 + \frac{p}{100}\right) \times m - 1}$$

***Additional conditions of level 3*** are presented in the table 2. Student should choose another three cards at random. After making decision student should write the criteria for the optimal choice of a bank of:

1) Reducing the time required to accumulate the required amount (early closing of the deposit).

2) Reducing the amount of overpayment on the loan.

***Additional conditions of level 4*** are presented in the table 3. Student should choose three cards at random.

**Table 3.** The various cards of chance events on the fourth level

| *Chance event* | *n* | *d* |
|---|---|---|
| In **n** months after signing the agreement with the bank, you will receive a notification that your bank has gone bankrupt. You must close the account or repay the loan within **d** days. | 2; 3; 4; 5; 6; 7; 8; 9 | 2; 3; 4; 5; 6; 7; 8; 9 |
| Unaware of your plans, Tanya will take part in the "Super game" lottery, the main prize of which is the iPhone. She will spend **n** thousand rubles of family budget on buying tickets. Her winnings will be **d** thousand rubles (if m is 9, then she won the phone). | | |
| In **n** months after the signing of the agreement with the bank, the ruble will devalue, as a result of which all imported goods have risen in price by 0.1**d** times, including the prices for the iPhone (phone price jumped sharply) | | |

***Decision making of level 4*** (Fig. 1):

1) In case of bankruptcy of a bank, the required amount to repay the loan (annuity payment) is:

$$\frac{(m-n)}{m} \times C \times \left(1 + \frac{p \times d}{100 \times 365}\right) = x_{n+1}$$

Win condition: $x_{n+1} \leq S \times \left(1 + \frac{s}{100}\right) - E \times \left(1 + \frac{e}{100}\right)$

2) In case of bank bankruptcy, the required amount to repay the loan (differential payment) is:

$$C \times q^n - x \times \left(\frac{1-q^{n-1}}{1-q}\right) \times \left(1 - \frac{p \times d}{100 \times 365}\right) = x_{n+1}$$

***Additional conditions of level 5***:

At this level, children are told about the number of cards of one type in the stack of cards. Children need to make decisions based on the likelihood of the risk of each event. Cards are not returned to the stack of cards.

**Conclusion**

As we can see, the model will allow to classify the existing and used in teaching mathematics tasks for improving financial literacy. Also, this model is based on the PISA standard and on the System (frame) financial capability for school age pupils. It will allow developers of mathematical tasks for improving financial literacy to use the model as a basis. The proposed theoretical model allows us to reveal the connection between different levels of decision-making in the formation of financial literacy of schoolchildren. The theoretical model fits well with the practical model. In this case, it is an economic and mathematical game with an interesting plot.

## NOTES

1. Strategy for financial literacy in the Russian Federation for 2017 – 2023 Approved by Order of the Government of the Russian Federation of September 25, 2017 №. 2039-r, 2017, https://www.garant.ru/products/ipo/prime/doc/71675558/#26 (last visited 28.01.2021).
2. Main directions of development of the financial market for the period 2019 – 2021 years, 2018, http://pfo.gov.ru/media/files/file/BFU6fPEfjnxfX14CXGlPMO5F6rahii6L.pdf, (last visited 09.09.2020).
3. List of activities Ministry of education and science of Russia and Bank of Russia in improving the financial literacy of students of educational institutions in Russian Federation to 2017 – 2021 (action Plan from 18.04.2017 No. PM-01 – 59 / 12), 2017, https://edu.gov39.ru/dlya-detey-i-roditeley/finansovaya-gramotnost/PM_minobrnauki.pdf (last visited 29.09.2020).
4. OECD (2019). PISA 2021 Financial literacy analytical and assessment framework, OECD Publishing, https://www.oecd.org/pisa/sitedocument/PISA-2021-financial-literacy-framework.pdf, (last visited 28.01.2021).
5. The project of the Ministry of Finance of the Russian Federation and the World Bank "Promoting the increase of the level of financial literacy of the population and the development of financial education in the Russian Federation", 2011, https://minfin.gov.ru/ru/om/fingram/about/targets/ (last visited 28.01.2021).

**REFERENCES**

Nikolaev, R., Grozdev, S., Koneva, B., Patronova, N. & Shabanova M. (2019).
Bulgarian Olympiad on financial and actuarial mathematics in Russia. *Mathematics and Informatics,* V. 62. № 6, 676 – 693.

✉ **Bogdana Koneva, PhD student**
Northern (Arctic) Federal University named after M.V. Lomonosov
17, Severnaya Dvina Emb.
Arkhangelsk, Russian Federation
E-mail: b.koneva@mail.ru

✉ **Prof. Maria Shabanova, DSc.**
Northern (Arctic) Federal University named after M.V. Lomonosov
17, Severnaya Dvina Emb.
Arkhangelsk, Russian Federation
E-mail: shabanova.maria-pomorsu@yandex.ru