Journal of Physics: Conference Series **2288** (2022) 012020 doi:10.1088/1742-6596/2288/1/012020

A model of learning the online course "Creative Thinking through Learning Elementary Maths"

V V Achkan[1], K V Vlasenko[2,3], O O Chumak[4], I V Sitak[5] and D A Kovalenko[5]

[1] Berdyansk State Pedagogical University, 4 Schmidta Str., Berdyansk, 71118, Ukraine
[2] National University of "Kyiv Mohyla Academy", 2 Skovorody Str., Kyiv, 04070, Ukraine
[3] Limited Liability Company Technical University "Metinvest Polytechnic", 71-A Sechenov Str., Mariupol, 87524, Ukraine
[4] Donbas National Academy of Civil Engineering and Architecture, 14 Lazo Str., Kramatorsk, 84333, Ukraine
[5] Volodymyr Dahl East Ukrainian National University, 59-A Tsentralnyi Ave., Severodonetsk, 93400, Ukraine

E-mail: vvachkan@ukr.net, vlasenkokv@ukr.net, chumakelena17@gmail.com, sitakirina@gmail.com, daria.kovalenko07@gmail.com

Abstract. The article considers the development of the online educational model "Creative Thinking through Learning Elementary Maths" and the results of the efficiency to implement this course for students of the specialization "Mathematics" while learning Elementary Mathematics. The research represents the development of learning materials for the online course posted in free access on the educational platform "Higher School Mathematics Teacher". The course components (theoretical, practical, and feedback) are focused on the organization of motivated and consistent students' activity; open and integrative Rich tasks of three levels of complexity. The course participants' activity, focused on the recognition, classification, solution, creation of Rich tasks, encourages the formation of the main components of creative thinking that include a problem statement, fluency, flexibility, originality, and elaboration. The first version of the course materials was improved following course users' wishes, and then the efficiency of online course education was checked using an experiment. The analysis of results of the experiment allows concluding about the efficiency of the developed model of learning an online course.

1. Introduction

1.1. Problem statement

According to the World Class Standards for Preparing Teachers of Mathematics [1] the development of creative thinking is one of the necessary components of the Mathematics teacher's training. The same document also mentions that the development of all key qualities of a would-be teacher takes place while teaching normative and optional subjects. Elementary Mathematics is one of the most important normative subjects while training students of the specialization "Mathematics". According to Vlasenko et al. [2], students' revision, generalization, and extension of knowledge in mathematical terms and facts that were considered during the school course of mathematics take place while learning this subject.

Our research follows the idea given by Noreen and Rana [3], Ahn and Edwin [4] that the formation and development of key personal qualities (including creative thinking) while learning Mathematics should be based on the active approach to learning. Scientists' conclusions prove that it is motivated and organized students' activity while learning that allows forming the necessary qualities. The types of activity and problems that students follow while learning depends on the qualities that the teacher is planning to form.

Nowadays, education is aimed at searching the ways to enable the organization of students' extracurricular activities. Thus, learning through online courses is getting more popular in the modern conditions of education development, and the idea given by Vlasenko et al. [2] about the development of the online course "Creative Thinking through Learning Elementary Maths" [5], which is focused on the development of creative thinking with systematized types of problems, is appropriate. This fact proves the actuality of the matter to create a model of learning this online course.

1.2. Analysis of the latest researches and publications

The matters of implementing online courses in learning Mathematics are considered in the researchers conducted by Vlasenko et al. [6], Wajeeh D. et al. [7], Ahn and Edwin [4] etc. In particular, the work which was done by Vlasenko et al. [6] represents the methodology of developing learning materials for the online course "Project method in teaching higher mathematics" [5]. The research by Ahn and Edwin [4] is dedicated to the use of efficient methods for learning mathematics online based on the active approach on the open platform of electronic education. Wajeeh et al. [7] describe the factors that affect the effectiveness of online courses for would-be math teachers. Scientists explain the importance of considering personal qualities and the selection of types of activity for students while learning. The above-mentioned scientists agree that online learning of mathematics has powerful potential and can be organized following the active approach to education, clear explanation of theoretical facts.

The process of building a model of learning the online course is considered in the works written by Ahn and Edwin [4]. Ahn and Edwin [4] mention a model of learning mathematics, based on the principles of social constructivism, social realism, connectivism, and it includes the organization of students' interactive activity to solve mathematical problems. Raza and Reddy [8] emphasize the importance of organizing problem activities and organizing effective feedback in synchronous and asynchronous mode as a condition for activation and interest of students in the process of mastering the online course. Our research considers the scientists' ideas on the relevance of organizing free communication in two directions "student-teacher" and "student-student". Puzziferro and Shelton [9] emphasize that, first of all, the efficient model of the online course, includes the completion of practical tasks using the methods of active learning and organization of feedback between the teacher and course participants. All the scientists agree about the necessity to build a model considering the active approach and efficient organization of feedback.

The active approach during the organization of the online course is considered in the researchers conducted by Moreno-Guerrero et al. [10], Hjalmarson [11] and Poultsakis et al. [12]. Moreno-Guerrero et al. [10] dedicated their research to the efficiency of electronic education as a method to form motivation, skills for self-education, and self-development while learning mathematics. The scientists mention that the organization of online and offline activities with properly selected problems encourages the formation of such qualities as self-organization and self-development. Poultsakis et al. [12] show teachers the importance of mastering digital object management technologies and modeling virtual experiments for online-based online learning.

The results of the research conducted by Hjalmarson [11] prove that all the key personal qualities of a mathematics teacher are developed during this activity (specifically organized practical – focused activity) while learning online. The development of the idea to organize

practical-focused activity is stated in the works done by Kajander at el. [13], who emphasize the importance of specifically selected problems in this process.

We find the same point of view in the researchers conducted by Gojak [14], Yeo [15], who states that the development of students' creativity can take place while solving particular types of problems. Among the methods that encourage the development of students' creative thinking, the scientists highlight Rich tasks. This idea is agreed with the conclusions of the research conducted by Vlasenko et al. [2]. The scientists consider Rich tasks in Elementary Mathematics as the tasks that increase the interest in mathematics as a science because they enable students "to open" new mathematical rules (terms, patterns), act outside the box; develop creative thinking, interest in the creation of their mathematical product. In this document, scientists define five main components of developing participants' creative thinking (a problem statement, fluency, originality or creativity, elaboration).

The scientists recommend the development of the online course "Creative Thinking through Learning Elementary Maths" for the efficient formation of the mentioned components of creative thinking [2]. The idea of creating this course was approved during the conference "Icon-MaSTed" [16]. So, the article is aimed at representing an educational model of the online course "Creative Thinking through Learning Elementary Maths" [5] and at proving the efficiency of implementing this course while training students of the specialization "Mathematics".

2. Method

The active approach to learning is the basis of the developed course "Creative Thinking through Learning Elementary Maths" [5]. The foundation for the formation of five main components of creative thinking was the students' work with two types of Rich tasks (open and integrative). Based on the analysis of the views of scientists presented in table 1 on the learning of Elementary Mathematics to the main types of participants' activities while working with the course materials are their recognition, classification, solution, and creation.

In particular, the activity to recognize Rich tasks encourages the formation of such a component of creative thinking as a problem statement. The participants get a task (to determine if a particular problem is related to Rich tasks or some specific types of Rich tasks), formulate the problem, get acquainted with the criteria of Rich tasks, find out if the task satisfies these criteria, and make a conclusion. Thus, the solution to the problem encourages the formation of such components as fluency, flexibility, originality, elaboration.

Considering the opinion given by Vlasenko et al. [16], Ahn and Edwin [4], Moreno-Guerrero et al. [10], Wajeeh et al. [7], Gojak [14], Kajander at el. [13] we built a model of the online course "Creative Thinking through Learning Elementary Maths" [5] represented in figure 1. The scientific novelty of the model is that all the traditional components of the course (theoretical, practical and feedback component) are focused on the organization of four activities with a special type of task (Rich task). It is the activity orientation of the online course on the use of Rich tack that is the basis around which the course model was developed. The model includes three interconnected components of the course (theoretical, practical, and forum for feedback) and implies a motivated students' activity with Rich task.

The course is meant for students of the specializations "Mathematics" and "Natural sciences" of pedagogical and classical universities, postgraduate students who are interested in the efficient methods of forming creative thinking through solving problems of Elementary Mathematics.

Six lessons of the course are given in Ukrainian. The course lasts four weeks. The user can start learning at any convenient time and follow their pace. We assessed the maximum time for working with every class and it is 4 hours. The total time of working with the course is 24 hours.

Let's describe the blocks of the course.

The 1st block. The theoretical component of the course. This block includes the main

Table 1. Analysis of the views of the scientists and online resources on the types of activities with Rich tacks and their impact on the development of students' personalities.

Resource	Rich tacks used during training	Rich tacks activities	What components of personality are developed by working with Rich tacks
Creative Thinking: Innovative Solutions to Complex Challenges [17]	Business management	Creation, solution, comparison	Ability to pose and solve problems, generate a large number of original ideas
Universalclass. Creative Thinking [18]	A course aimed at the general development of creative personality traits	Recognition and comparison	Ability to solve problems, flexibility of thinking, ability to analyze and highlight the basics
European Schoolnet Academy. Developing Creative Thinking Skills in Practice – are my students learning to creatively solve problems [19]	Higher school teachers. A course aimed at the general development of creative personality traits	Recognition and classification	Ability to pose the problem, originality, ability to continuous improvement
School Education Gate Way. Creativity for the future: promoting Critical Thinking and Problem-Solving in the classroom [20]	Teachers and education managers. A course aimed at the general development of creative personality traits	Creation and solution	Ability to pose and solve problems, generate a significant amount of original ideas, flexibility of thinking

theoretical data on every lesson that is necessary for the participants to achieve the goal of the course and audio presentations that explain the main theoretical questions of the course. Let's state the topics of the course.

Lesson № 1. Creative thinking and its structure.
Lesson № 2. The role of Elementary Mathematics in the development of creative thinking.
Lesson № 3. Open tasks in Elementary Mathematics.
Lesson № 4. Types of open tasks in Elementary Mathematics.
Lesson № 5. Integrative tasks in Elementary Mathematics.
Lesson № 6. Types of integrative tasks in Elementary Mathematics.

The acquaintance with the theoretical component of the course encourages the students to do the following types of Rich tasks: recognition, classification, and solution. In particular, in the second lesson, the users get acquainted with several approaches to the classification of Rich tasks, their special features, and types. This encourages the primary organization of the activity to recognize Rich tasks. After learning the theoretical block the course participants improve their recognition skills while doing the practical tasks.

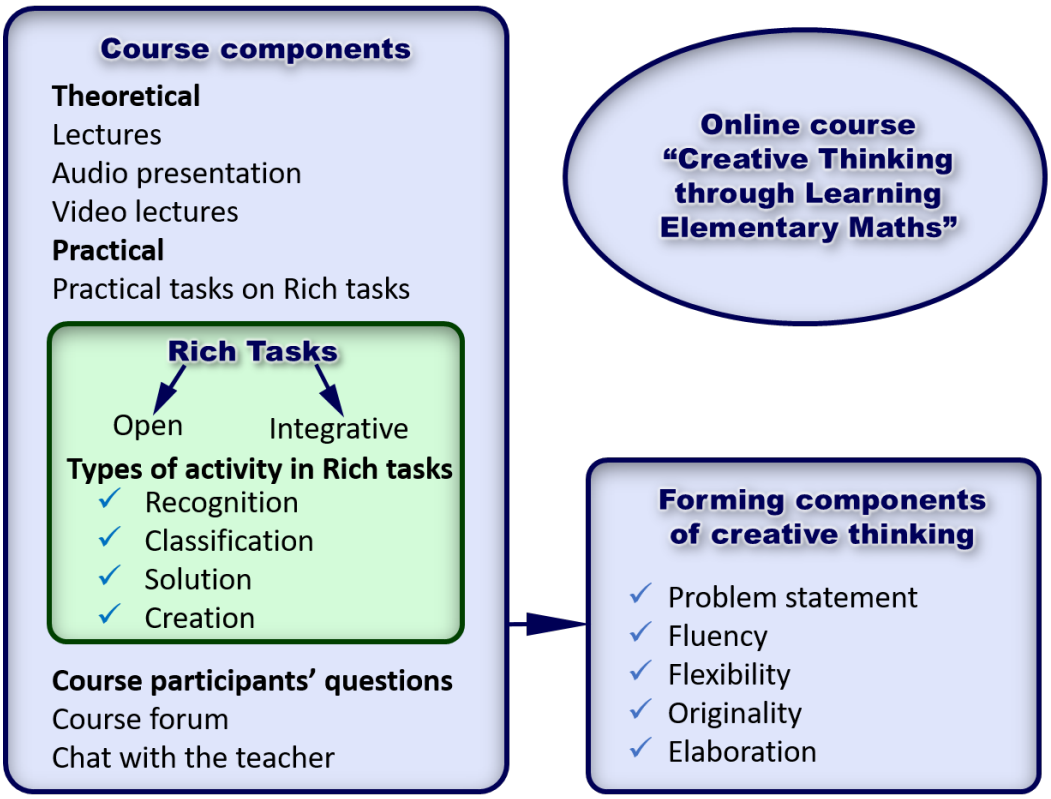

Figure 1. Model of learning online course "Creative Thinking through Learning Elementary Maths".

At the third, fourth, fifth, and sixth lessons, the users get acquainted with open and integrative Rich tasks, their examples, types, and methods of their solution. This encourages the primary organization of the classification and solution of Rich tasks. The course participants master their skills to classify and solve problems while completing practical tasks.

The second block. The practical component of the course. This block includes:

Practical tasks connected with the analysis of different aspects of developing creative thinking, the analysis of methods to learn Elementary Mathematics aimed at the development of creative thinking, comparisons, solutions, building Rich tasks of Elementary Mathematics. Completing practical tasks of the course encourages such types of activity with Rich tasks among students as recognition, classification, solution, and creation.

Several examples of the tasks aimed at carrying out all the mentioned types of activity are represented in table 2.

The third block. Course participants' questions which the course moderators can be asked on the forum and in the chat with a teacher. Participants' ideas on the course improvement can be expressed.

The third block helps to eliminate the problems in organizing the recognition, classification, solution, and construction of Rich tasks that were completed during the first two blocks. Also, the third block helps the teachers to improve the learning material of the first two course blocks.

3. Results

The first version of the course was offered for students of the 1st–2nd year of Berdiansk state pedagogical university, Kryvyi Rih State Pedagogical University, Donbas Machinery Building

Table 2. Examples of practical tasks aimed at completing particular types of activity with Rich tasks.

Type of activity	Examples	Comment
Recognition	1. Can we relate such tasks to Rich tasks? Prove your mind. A. Simplify the expression: $\frac{\sin 80^\circ}{2\cos^2 40^\circ}$. B. The perimeter of the parallelogram is $20cm$, and its height is $2cm$. and $3cm$. Create two tasks of different levels of complexity using these conditions (no more than one condition can be added). 2. Which of the stated problems can be related to open Rich tasks? Prove your mind. A. Solve the equation $\sqrt{2+\sqrt{2+\sqrt{2+x}}} = x$. B. Define the approaches of solving irrational equations and inequalities and an approximate basis of activity on using these approaches while analyzing the educational materials on Elementary Mathematics and school textbooks.	Problem statement as a component of creative thinking is formed while completing this task.
Classification	Which types of Rich tasks are the problems related to? A. the endless chessboard there are two white officers on two neighboring diagonal squares. What part of the board is under the attack of these officers? B. The foundation of an isosceles pyramid is an isosceles triangle which height is $9cm$ and the platform is $6cm$. Create three problems of different levels of complexity using these conditions (no more than one condition can be added). C. Sunbeams going through small holes between the leaves of the tree create light spots on the ground in form of ellipses of the same form, but different size. The bigger axis of the ellipses is $a = 16cm$, and the smaller axis is $b = 12cm$. What is the height of the tree? Under which angle to the horizon do the sunbeams fall? The angle size of the sun disk is $\beta = 9.3 \cdot 10^{-3} rad$.	While solving such a problem the participants determine the problems as open or integrative Rich tasks, later on, they learn to define the varieties of open and integrative Rich tasks. Such activity encourages the formation of such components of creative thinking as a problem statement and flexibility.

Solution	1. Classify the types of problems following the topic "Polygon"; show the main methods (means) of solving the problems using two of the types which you suggest. 2. One student has 6 books on Mathematics, the other one – 8. Create and solve two problems of different levels of complexity on combinatorics, under this condition. 3. Prove that for all $0 < x < y\frac{\pi}{2}$ there is an inequality $\frac{y}{x} < \frac{\tan y}{\tan x}$. 4. The bus is moving on a straight highway with a speed of $18m/s$. There is a person in the field in front of the bus, in the distance of $90m$ from the highway and $500m$ from the bus and who can run with the speed of $5m/s$. What direction should he/she run to be able to "catch" the bus?	While solving these problems the participants learn to summarize, use the mathematical machine beyond mathematics, understand the connection between Elementary Mathematics and mathematical analysis (while solving the third problem). The next components of creative thinking are formed: fluency, flexibility, and originality.
Creation	1. Create three problems (problematic situations) in Elementary Mathematics. 2. Create one task for each problem with an open ending with equations, polygons, random events in the condition. 3. Create one task for each problem the solution of which will enhance the understanding of connections between Elementary Mathematics and Mathematical Analysis, Geometry, Mathematical Logic.	While building the varieties of open and integrative Rich tasks the participants form the following components of creative thinking: fluency, flexibility, originality and elaboration.

Academy, Uman State Pedagogical University named after P. Tychyna, Glukhiv National Pedagogical University in 2019 – 2020. The students were surveyed on the forum of the platform "Higher School Mathematics Teacher" [21] about the test improvement. 65% of respondents were willing to get more examples of Rich tasks, 60% of students would like to have clearer guidelines about the systematization and creation of open and integrative problems in Elementary Mathematics, 53% of students were willing to have online consultations while completing tasks of the practical part of the course. We changed the materials of the course according to the needs of its users. Students' ideas influenced the increase of examples in all types of Rich tasks during practical classes 2-6 and definition of the main requirements to the creation of an open and integrative Rick task during practical lessons 3 and 6.

The efficiency to implement the online course was checked in April-November 2020. 87 students of the 1st-2nd year from the same universities who took part in the first stage of implementing the first version of the course were engaged in the experiment. At the beginning of the experiment the participants were accidentally divided into control (CG) and experimental (EG) groups. In the control group, 43 students learned the course of Elementary Mathematics using traditional tasks. In the experimental group, 44 students followed the program "Creative Thinking through Learning Elementary Mathematics".

Table 3. The results of diagnostic tests in Elementary Mathematics at the beginning of the experiment.

The level of student achievement CG				The level of student achievement EG			
1–49 points	50–75 points	76–89 points	90–100 points	1–49 points	50–75 points	76–89 points	90–100 points
1 (2%)	16 (37%)	17 (40%)	9 (21%)	1 (2%)	17 (39%)	16 (36%)	10 (23%)

To confirm the homogeneity of the groups at the beginning of the experiment, diagnostic tests in Elementary Mathematics were used, which contained 5 "traditional" and 5 Rich tasks.

As we see in table 3 the results of diagnostic tests in the control and experimental groups at the beginning of the experiment are almost the same. In particular, the largest difference of 4% was observed between students who scored 76 – 89 points in favor of the control group (figure 2).

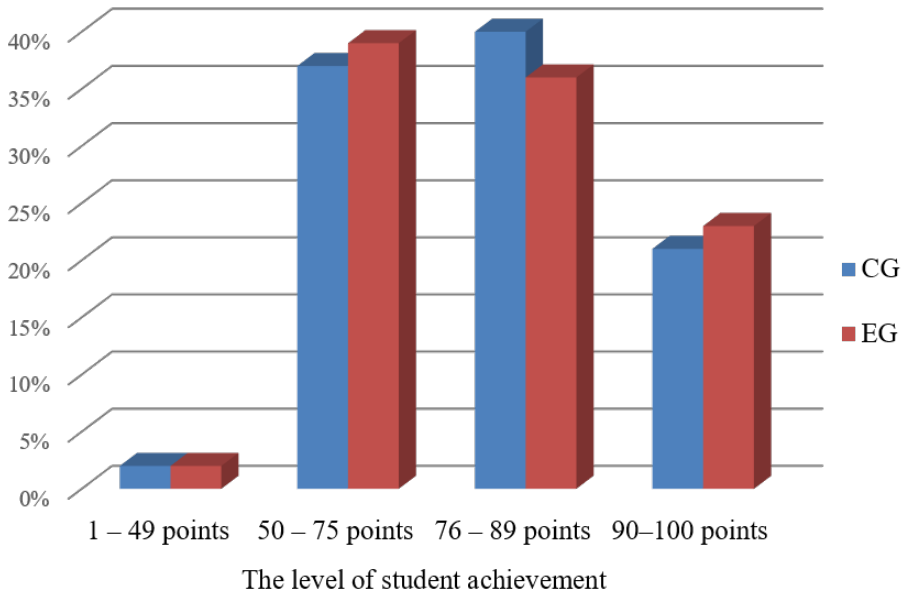

Figure 2. The results of diagnostic tests at the beginning of the experiment.

The students of CG learned the course of Elementary Mathematics in universities without using the course "Creative Thinking through Learning Elementary Maths" [5]. The students of EG learned the course of Elementary Mathematics and during 6 weeks were involved in the development of the course. The students of EG could get acquainted with the theoretical material, watched the audio presentations, worked with video lectures, got practical tasks of the course. Using Google class students could send the completed practical tasks for the teacher to check. The task assessment was carried out using the scale "accepted" or "not accepted". The teacher pointed out the mistakes and incorrectness in the completed tasks, allowed correcting them when the mark was "not accepted". Students could ask a question or get a consultation

Table 4. The results of diagnostic tests in Elementary Mathematics at the end of the experiment.

The level of student achievement CG				The level of student achievement EG			
1–49 points	50–75 points	76–89 points	90–100 points	1–49 points	50–75 points	76–89 points	90–100 points
1 (2%)	15 (35%)	18 (42%)	9 (21%)	0 (0%)	6 (14%)	21 (48%)	17 (38%)

on the forum of "Higher School Mathematics Teacher" [21] or in Google chat.

At the end of the experiment, the students were also surveyed using tests in Elementary Mathematics, which contained the same number of traditional tasks and all kinds of Rich tasks.

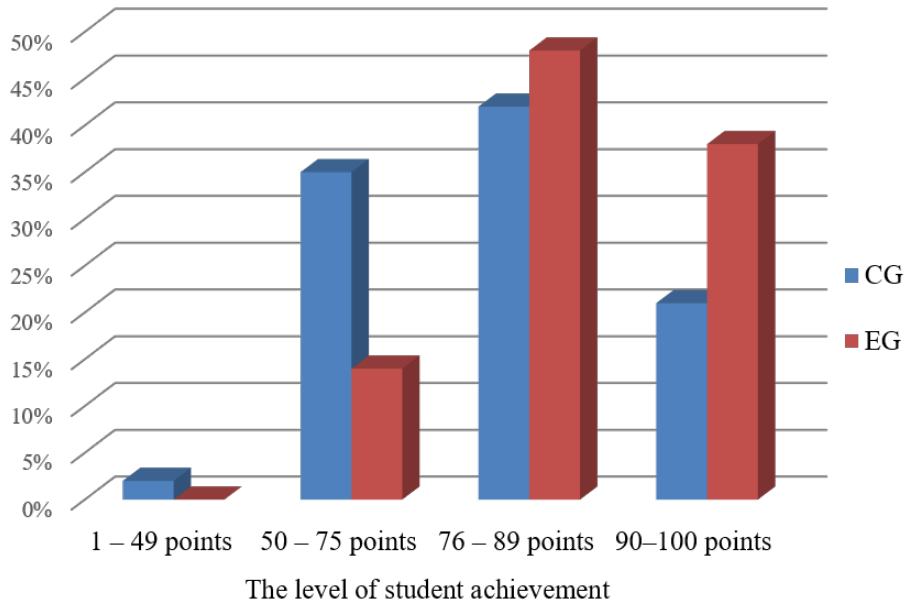

Figure 3. The results of diagnostic tests at the end of the experiment.

As can be seen in table 4, the results of control works in the control and experimental groups at the end of the experiment differ significantly. In particular (figure 3), the largest difference of 18% was observed between students who scored 50 – 75 points in favor of the control group, while the difference of 16% was observed between students who scored 90-100 points in favor of the experimental group. Fisher's statistical test φ^* was used to ensure that the difference between the results of the diagnostic tests in the control and experimental groups was statistically significant.

We formulate statistical hypotheses. Zero hypothesis H_0: the level of formation of educational achievements of students of control and experimental groups does not differ statistically significantly. Then the alternative hypothesis H_1: the level of formation of educational achievements of students of control and experimental groups is statistically significantly different.

Determine: $\varphi_1(86\%) = 2.373$, $\varphi_1(63\%) = 1.831$.

Table 5. Table for calculating the criterion φ^* for comparing the level of student achievement at the end of the experiment.

Group	"There is an effect", scored points from 7 to 12	"No effect", scored points from 1 to 6	Total
Control	27 (63%)	16 (37%)	43
Experimental	38 (86%)	6 (14%)	44
Total	65	22	87

Hence we have the empirical φ^*:
$\varphi^*_{empirical} = (\varphi_1 - \varphi_2)\sqrt{\frac{n_1 \cdot n_2}{n_1+n_2}} = (2.373 - 1.831) \cdot \sqrt{\frac{44 \cdot 43}{44+43}} \approx 2.53.$
The critical value φ^* for any n_1 and n_2 is equal to $\varphi^*_{critical} = \begin{cases} 1.64 & (p \leq 0.05) \\ 2.31 & (p \leq 0.01) \end{cases}$.
So, according to $\varphi^*_{empirical} \approx 2.53$ we have that $\varphi^*_{empirical} > \varphi^*_{critical}$.

Based on this, the hypothesis H_0 is refuted and H_1 accepted. Thus, the level of formation of educational achievements of students of control and experimental groups is statistically significantly different. And the data given in table 5 give grounds to claim that the level of academic achievement of students in the control group is higher than in the experimental group.

This allows stating about the efficiency of using the online course "Creative Thinking through Learning Elementary Maths" [5] as a method to form key components of creative thinking.

4. Discussion

According to Papadakis et al. [22], Perikos et al. [23], Harpen and Sriraman [24], and Maharani [25] the developed creative thinking is important for any specialist who wants to be competitive in the modern globalized world. Specialists in mathematics are not an exception. This is agreed with the conclusions that are made by Moreno-Guerrero et al. [10], who state that learning Mathematics using online courses is efficient to form the person's creative thinking.

While developing the online course model we considered the opinions stated by Burgess et al. [26], Donnelly and Agius [27], Puzziferro and Shelton [9], Lockwood [28] about the relevance of providing learning materials in different forms such as tables, schemes, audio presentations, video-lectures. At the same time, we considered the recommendations stated by Im and Chee [29] about the importance of organizing efficient feedback with students through forums and chats.

Also, while developing a model the researches by Wajeeh et al. [7], Hjalmarson [11] had an important role and they stated that the development of personal qualities should take place during specifically selected types of activity. Based on the views of these scholars, we have focused each component of the traditional triad of online courses (theoretical, practical and feedback) on four types of activity (recognition, classification, solution, creation) with open and integrative Rich tasks, the formation of all components of course participants' creative thinking takes place [2]. Agreeing with Poultsakis et al. on the importance of building digital object management skills in online courses, we believe that it is equally important (and our research confirms this) to build targeted mindfulness skills with Rich tasks. Thus, solving Rich tasks, a student learns to formulate a problem (a problem statement), opens or offers an unusual (unknown) method, method of solution (formation of originality and fluency), clarifies, changes the way of a solution in case of difficulties (formation of flexibility and elaboration). The student learns to think outside the box, change, improve the condition, and adapt it to the students'

needs (formation of originality, flexibility, and fluency).

5. Conclusions

The analysis of the online education experts' resources and scientific researches proved the conclusion about the necessity to develop a model of the online course "Creative Thinking through Learning Elementary Maths" [5]. The peculiarity and uniqueness of the course model is that three main components are determined it (theoretical, practical, and feedback) that are aimed at the students' activity with Rich tasks as a method to develop creative thinking while learning Elementary Mathematics. Posting the course on the platform "Higher School Mathematics Teacher" [21] allowed providing access to it for a large group of students. The students had access to theoretical data with examples and explanations in PDF-documents, audio presentations, and video lectures. Practical tasks were focused on the organization of students' activity with Rich tasks of three levels of complexity. The preliminary approbation of the course, discussion on the platform forum allowed improving its content and organization of learning with its help. Also, it allowed considering the course users' preferences related to information perception and posting. The experimental verification of implementing the improved course proved the efficiency of the course use to form its users' creative thinking. The experiment showed that users' acquaintance with Rich tasks and their varieties (open and integrative problems), organization of their activity on recognition, classification, solution, and creation of Rich tasks encouraged the development of a problem statement, elaboration, fluency, flexibility, and originality. This allows us to argue for the effectiveness of the activity-based online course model; expediency of introduction of a new type of tasks in the process of development of creative thinking in the process of distance learning of Elementary Mathematics – Rich tasks.

We see further perspectives in the development of the methodology to develop students' creative thinking while completing Rich tasks, developing and testing the effectiveness of Rich tasks for the formation of key competencies of the personality of high school students.

ORCID iDs

V V Achkan https://orcid.org/0000-0001-8669-6202
K V Vlasenko https://orcid.org/0000-0002-8920-5680
O O Chumak https://orcid.org/0000-0002-3722-6826
I V Sitak https://orcid.org/0000-0003-2593-1293
D A Kovalenko https://orcid.org/0000-0002-1362-9241

References

[1] Schmidt W, Burroughs N and Cogan L 2013 World Class Standards for Preparing Teachers of Mathematics URL https://eric.ed.gov/?id=ED558128
[2] Vlasenko K, Achkan V, Chumak O, Lovianova I and Armash T 2020 *Universal Journal of Educational Research* **8** 2853–2863 URL https://doi.org/10.13189/ujer.2020.080712
[3] Noreen R and Rana A M K 2019 *Bulletin of Education and Research* **41** 145–159 URL https://eric.ed.gov/?id=EJ1229426
[4] Ahn J Y and Edwin A 2018 *International Review of Research in Open and Distributed Learning* **19** 255–267 URL https://eric.ed.gov/?id=EJ1198098
[5] Creative Thinking Through Learning Elementary Maths (Higher School Mathematics Teacher, 2019) URL http://formathematics.com/courses/imt/open-and-integrated-tasks-of-elementary-mathematics/
[6] Vlasenko K, Kondratyeva O, Khyzhniak I, Chumak O and Volkov S 2020 Developing training materials for the on-line course "Project Method in Teaching Higher Mathematics" *CEUR Workshop Proceedings* vol 2732 pp 756–769 URL http://ceur-ws.org/Vol-2732/20200756.pdf
[7] Daher W, Sabbah K and Abuzant M 2021 *Emerging Science Journal* **5** 545–558 URL https://doi.org/10.28991/esj-2021-01296

[8] Raza S and Reddy E 2021 *Frontiers in Applied Mathematics and Statistics* **7** URL https://doi.org/10.3389/fams.2021.612327
[9] Puzziferro M and Shelton K 2008 *Journal of Asynchronous Learning Networks* **12** 119–136 URL https://eric.ed.gov/?id=EJ837519
[10] Moreno-Guerrero A J, Aznar-Díaz I, Cáceres-Reche P and Alonso-García S 2020 *Mathematics* **8** URL https://doi.org/10.3390/MATH8050840
[11] Hjalmarson M 2017 *Journal of Mathematics Teacher Education* **20** 281–301 URL https://doi.org/10.1007/s10857-015-9323-x
[12] Poultsakis S, Papadakis S, Kalogiannakis M and Psycharis S 2021 *Advances in Mobile Learning Educational Research* **1** 58–71 URL https://doi.org/10.25082/AMLER.2021.02.002
[13] Kajander A, Manuel D and Sriraman B 2014 Exploring creativity: from the mathematics classroom to the mathematicians' mind *Proceedings of the 2013 Annual Canadian Mathematics Education Study Group* pp 57–90
[14] Gojak L 2013 A Key to Deep Understanding: The Importance of Rich Tasks in K-12 Mathematics URL https://s3.amazonaws.com/ecommerce-prod.mheducation.com/unitas/school/explore/research/reveal-math-rich-tasks-white-paper.pdf
[15] Yeo J 2007 Mathematical Tasks: Clarification, Classification and Choice of Suitable Tasks for Different Types of Learning and Assessment URL https://repository.nie.edu.sg/bitstream/10497/949/3/MathematicalTasks.pdf
[16] Vlasenko K, Chumak O, Achkan V, Lovianova I and Kondratyeva O 2020 *Universal Journal of Educational Research* **8** 3527–3535 URL https://doi.org/10.13189/ujer.2020.080828
[17] Creative Thinking: Innovative Solutions to Complex Challenges URL https://pll.harvard.edu/course/creative-thinking-innovative-solutions-complex-challenges?delta=5
[18] Universalclass. Creative Thinking URL https://www.universalclass.com/i/course/creative-thinking.htm
[19] European Schoolnet Academy. Developing Creative Thinking Skills in Practice – are my students learning to creatively solve problems? URL https://www.europeanschoolnetacademy.eu/courses/course-v1:TeachUP+TU4_Creative_EN+2019/course/
[20] SchoolEducationGateWay. Creativity for the future: promoting Critical Thinking and Problem-Solving in the classroom URL https://www.schooleducationgateway.eu/en/pub/teacher_academy/catalogue/detail.cfm?id=85064
[21] Higher School Mathematics Teacher URL http://formathematics.com/
[22] Papadakis S, Kalogiannakis M and Zaranis N 2017 *Early Childhood Education Journal* **45** 369–378 URL https://doi.org/10.1007/s10643-015-0768-4
[23] Perikos I, Grivokostopoulou F, Kovas K and Hatzilygeroudis I 2015 Assisting Tutors to Utilize Web 2.0 Tools in Education *Proceedings of the International Conference on e-Learning 2015* pp 121–128 URL https://files.eric.ed.gov/fulltext/ED562502.pdf
[24] Van Harpen X Y and Sriraman B 2013 *Educational Studies in Mathematics* **82** 201–221 URL https://doi.org/10.1007/s10649-012-9419-5
[25] Maharani 014 Creative Thinking in Mathematics: are We Able to Solve Mathematical Problems in a Variety of Way? *International Conference on Mathematics, Science, and Education (ICMSE)* pp 120–125 URL http://research.unissula.ac.id/file/publikasi/211313016/402521.pdf
[26] Burgess G, Holt A and Agius R 2005 *Occupational Medicine* **55** 312–318 URL https://doi.org/10.1093/occmed/kqi117
[27] Donnelly A and Agius R 2005 *Occupational Medicine* **55** 319–323 URL https://doi.org/10.1093/occmed/kqi130
[28] Lockwood F 1994 *Materials Production in Open and Distance Learning* (London: Paul Chapman Pub)
[29] Im E and Chee W 2012 *CIN: Computers, Informatics, Nursing* **30** 604–611 URL https://doi.org/10.1097/NXN.0b013e318266cade